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REPAIRING AND TESTING HOSE IS AN IMPORTANT FUNCTION OF THE FIRE DEPARTMENT REPAIR SHOPS. HERE A HOSE COUPLING IS BEING EXPANDED IN A LENGTH OF HOSE (See page 380)

The Commotional Factor in the Ætiology of Shell Shock*

Interesting Results of Experiments on Animals

By Alfred Carver, M. D., Camb.

In the Lancet of Jan. 11th, 1919, Dr. C. S. Myers raises three important questions relating to the problem of "shell shock." The first is as to "the existence of distinct commotional and emotional syndromes." I believe that the following experiments, carried out with the assistance of Lieutenant A. Dinsley, S.A.O.C., prior to the appearance of Dr. Myers's article, will prove of interest as bearing upon this point. The conditions under which "shell shock" arises in man render accurate observations so difficult that experiments upon animals seemed advisable carried out so that the weight of explosive used could be kept constant, its nature and composition known but varied at will, and the actual distance of the animals from the centre of detonation measured.

EFFECTS OF HIGH EXPLOSIVES.

When a high explosive is detonated there arises first a sudden terrific blow which exerts a compressing and shattering force upon its surroundings in every direction. This is instantaneous and is followed immediately by an equally sudden decompression, thirdly rapid oscillatory or vibrating movements are set up, which die down only gradually. Each of the three results requires analysis when considering the effects upon living organisms. A further effect is the purely demoralising effect produced by the vibrations outside the sphere within which any demonstrable physical destruction or injuries occur. Evidence will be adduced to show that the Germans arranged their shell-fillings so as to enhance this peculiar effect. This, fully in keeping with other of their methods, might be described as "frightfulness by detonation."

If a high explosive be detonated at a point X three zones may roughly be mapped out around it, their radii depending among other things, upon the weight of explosive.

Zone A is delimited by the extent of obvious gross disruption, and may be termed "the zone of brisance"; within it a crater is formed, barbed wire and other obstacles are blown aside, broken and distorted; animals are killed and usually lacerated; other high explosives immediately detonated.

Outside this is a second zone, B, which may be termed the "zone of decompression," for the disturbances within it seem mainly attributable to this factor, though coarse shaking movements also play their part. In zone B the gross effects of shattering and disruption are no longer evident; animals placed in it and protected from flying fragments rarely show external signs of injury; only sensitive explosives, whose tonal standard is somewhat similar to that of the primary explosive, detonate.

Beyond this can be named a zone, C, in which the effects of detonation are modified further. The effects upon animals in zone C vary considerably, but as a rule a short transitory state of stupor is followed by a stage of excitement.

EXPERIMENTS ON FISH.

Experiments were first carried out in water, the test animals being fish (perch); a depth charge of 6 oz. of gelignite was used.

Fish in zone A became obviously "hors de combat," showed gross lacerations, and were sometimes torn in pieces.

Fish in zone B after the detonation floated in an almost vertical position, but slightly inclined with their ventral surfaces uppermost, their mouths just protruding above the surface. At this early stage the whole of their bodies were rigid, and if the fish were pushed down to a depth of about two feet they sank slowly to the bottom of the tank and there remained. The earliest sign of animation was violent and irregular spasmodic movement of the opercula and gills. The first reflex which could be elicited from such fish was erection of the dorsal fin upon stimulation of the skin to either side of it. At the end of about half an hour those fish which eventually recovered began to swim when the abdomen was stroked with a piece of stick, but these first swimming movements carried the fish only forward in a straight line, and no turns were made even when an obstruction was met. The movements were made with the ventral surface uppermost and almost flush with the surface of the water. At this stage, then, the fish had lost their power of equilibration, and with this the whole of their orientation in life.

The majority of those which attained the stage of swimming in this way gradually became more active, and eventually, after passing through a side-uppermost posture, began to swim about in a natural manner. In about 12 hours after the detonation all those fish which had not succumbed were, to all appearances, completely normal.

Dissection of the dead ones showed definite congestion of the foreparts of the brain, hæmorrhagic points in the mid-brain and basal gangliar region, and generally hæmorrhage in the upper region of the spinal cord and medulla. The gills and other viscera, also the muscles attached to the vertebral column, frequently showed areas of hæmorrhage. Dissection of perch taken at random immediately after the detonation either revealed varying degrees of the above-described changes or else, at macroscopic examination, nothing abnormal was discovered.

TO OUR READERS

With this issue the career of the SCIENTIFIC AMERICAN SUPPLEMENT comes to a close and it is succeeded by the SCIENTIFIC AMERICAN MONTHLY. The change will be more than one of name and period of issue. The new journal will consist of ninety-six reading pages of large magazine size (nine by twelve inches) and will include many features which will prove invaluable.

A section of the SCIENTIFIC AMERICAN MONTHLY will be used as an official organ of the National Research Council to keep the public informed of the work the Council is doing in organizing scientific research and introducing it into our industries. The aim of the Council is to make science as important an adjunct of manufacture in this country as it is in Germany.

To further this laudable work we have also arranged with the United States Bureau of Standards to edit a Department in which the splendid research work of this branch of our Government service will be summarized and specially prepared for readers of the SCIENTIFIC AMERICAN MONTHLY. The National Academy of Sciences will also furnish material describing the progress of American men of science. Similar arrangements are being made with certain of the national technical societies so as to keep our readers in touch with the advance of science in various branches of technology.

We shall continue our policy of publishing the more important announcements of distinguished technologists, appearing in foreign as well as domestic publications, thereby reflecting the most advanced thought in science and technology throughout the world. In our columns will be found the complete text of significant European articles, furnishing often the only English translation of these papers that is obtainable.

Towards the outer margin of B zone and the inner region of C zone the effects upon fish could not be sharply differentiated, the severity of the symptoms and the anatomical findings gradually diminishing with the distance of the creature from X.

Fish well out in C zone dashed about vigorously in a disturbed and excited manner, but though their movements were wild and apparently haphazard they generally made away from X. A few came to the surface and splashed about, but when netted no physical abnormality could be demonstrated, and those returned to the water soon behaved in a completely normal manner.

In considering the effect upon fish of vibrations set up in water one should bear in mind the great development in these creatures of special senso organs directly susceptible to stimulation from such. It is conceivable that the effects of the violent vibrations just described are in part due to excessive stimulation of these special sense organs. If this be so, the shock, though still physical, might be more accurately described as of neurogenic than of commotional origin. It is well known that in man unconsciousness can be produced by purely reflex stimulation, the whole ego being swamped by an excessive flood of afferent impulses which gives rise to a condition of neurogenic shock; there being no "commotio." I have no evidence which leads me to think that neurogenic shock of this type plays any appreciable rôle in the production of the war neuroses.

EXPERIMENTS ON MAMMALS

Experiments with mammals (rats and mice) were carried out on land. Perforated zinc cages were used, partly to fix the position of the animals and partly to protect them from flying fragments. These cages were distributed at measured distances around X. The charge was standardised to 3 oz. of explosive.

In zone A cages in and immediately outside the crater formation were simply blown away and distorted, the animals being killed or severely wounded by direct violence; their eyes were bloodshot, and there was often external hæmorrhage from the ear, nose, or mouth. On dissection the alveoli of the lungs were found to be ruptured, and to a variable extent the central nervous system and other viscera showed hæmorrhagic areas. With the effect in A zone we are not further concerned; the changes would seem to be due to the direct blow of displaced air, which strikes like a solid substance, and to the effect of the exceedingly rapid decompression succeeding this.

Along the inner part of zone B the findings, though similar to the above, were much less in degree. Animals were invariably rendered unconscious irrespective of the extent or nature of the lesions demonstrable, and occasionally were found to be dead, even though no external injury was present; upon dissection the only abnormal finding, to coarse examination, was general capillary engorgement, especially noticeable in the central nervous system and meninges. Whether this indicates that vasomotor changes play any part in the associated phenomena I am not prepared to say.

Further out in zone B a state of stupor or transitory loss of consciousness, of much shorter duration than in zone A animals, was an almost constant result. During the stage of recovery twitching movements of the limbs were often present, and then the animals, if stimulated by appropriate physical agents, showed massive and exaggerated reflex reactions. For example, the application of a pin-prick to one hinder extremity might be followed either by bilateral contraction of the hinder extremities or even by a generalised convulsion. There was frequently considerable difference in the activity of the reflexes on the two sides of the body—a hemiplegic distribution—but, as a rule, the fore-limbs were more severely affected than the hind and showed weakness and dragging after the latter had recovered normal movements. Reflex responses, though vigorous, died away quickly, but were often succeeded by a weaker repetition even when no fresh stimulus was given. Rapid fatigue of the response on repeated stimulation was a noticeable feature. By dissection no gross macroscopical evidence of internal injury to such animals was revealed, but capillary engorgement, as in animals nearer X, was generally demonstrable.

Animals left alone after this stage had been reached gradually began to behave in a more normal manner, though for a considerable time their conduct, postures, and gaits were awkward. The severity of these disorders varied greatly from animal to animal, which rendered it impossible to deliminate, from biological observations, the precise boundaries of the several zones. Speaking generally, the effect diminished gradually in proportion to the distance of the animal from X.

For some distance beyond what I have termed the C zone, animals crouched down and huddled themselves together whenever a detonation took place; after this state of diminished activity a state of apparent excitement with increased restlessness was the rule. Animals left exposed in this position during a series of experiments invariably crouched down as flat as possible and seemed to be in an absolutely stuporose condition. When liberated they made no effort to run away but remained for a long time in a huddled-up posture. The interpretation of these latter peculiarities of behaviour is difficult. Should fear be allowed as the cause or are other more material factors also at work?

If instead of employing a single explosive at X one detonated a composite charge all the above phenomena became more pronounced, but the increased effect was particularly noticeable in zone C and its immediate surroundings.

OBSERVATIONS ON SOLDIERS.

In this connexion it is of interest to record some observations carried out upon physically and mentally fit men of an "Ammunition Proof and Demolition Section" during the ordinary course of their duties. The staff, drawn from infantry-men with some technical knowledge,

(*Continued on page* 388)

* From *The Lancet*.

A New Compensated Heatmeter

Eliminating the Effect of Line and Thermo-couple Resistance

By Charles P. Frey

UNTIL comparatively recently, the determination of furnace and kiln temperatures by means of thermo-couples was attended with complications and difficulties which made practical men impatient, and in some instances doubtful in regard to the intrinsic value and reliability of the method.

Technical men, however, have realized from the beginning that, within certain temperature limitations, the results obtained by the use of thermo-couples were not only accurate, but could be made "direct reading," provided that the thermo-couple be connected with a galvanometer which would indicate the actual value of the e.m.f. obtained by heating.

On first consideration, this problem did not seem difficult of solution, since it is an established fact that the e.m.f. or voltage of a thermo-couple bears a direct relation to the difference in temperature between its hot and cold ends. It is also true that the movable coil of a millivoltmeter will be deflected to an extent which is directly proportional to the e.m.f. of the thermo-couple. Therefore, it would seem the simplest operation imaginable to connect the thermo-couple and the instrument together by means of insulated conductors, figure the scale in temperature values, and regard the problem as solved.

Unfortunately, however, we have also to contend with factors which cannot be ignored if accurate results are required; namely, line resistance, thermo-couple resistance, and the resistance of the indicator itself; because, to be precise, a direct current millivoltmeter actually is not a millivoltmeter at all, except in name, but is a milliammeter or current indicator. All instruments of the d'Arsonval type depend primarily upon current for their operation, and the extent of the deflection obtained with any given current is established by the intensity of the magnetic field, the controlling force of the springs, and the number of convolutions or ampere turns in the movable coil; not by a remote e.m.f. Therefore, if the conductors which carry the current from the source of e.m.f. to the terminals of the instrument do not have a negligible resistance, then, in accordance with Ohms' law, there will be an appreciable fall of potential along the line, with the result that the movable system will receive a diminished current, and therefore be low in its readings. To reduce such errors to a minimum, it is desirable that the instrument resistance be as high as possible, so that the line and thermo-couple resistance may be proportionately insignificant. When this is not the case, if the resistance of the millivoltmeter (M) is 300 ohms, and the resistance of the line (A) and thermo-couple (C) is 3 ohms (see Fig. 1), the current through the circuit will be reduced practically 3 parts in 300, or one per cent., and the instrument indications will be one per cent. low. Figured in degrees Fahrenheit, this would mean an error of approximately 14° in 1400° Fahr., if a thermo-couple were used.

The advantage of high resistance instruments, therefore, becomes evident. For instance, if the pyrometer has a resistance of 600 instead of 300 ohms, and the line resistance remains the same, an error of 3 parts in 600 will result in error of only one-half per cent. instead of one per cent., or, about 7° Fahr. in 1400° Fahr.

Until within the last five years it was customary to use a so-called low-resistance pyrometer to measure the current from the thermo-couple. These instruments had from two to five ohms internal resistance and were naturally materially affected by the external resistance of the thermo-couple and leads. In the past few years high-resistance pyrometers have been almost universally adopted. These instruments have an internal resistance of usually from 300 to 1200 ohms. The higher the resistance naturally the less the effect on the readings due to variations in line resistance. But with increase in internal resistance, something had to be sacrificed, and usually control or torque is weakened. In consequence, the instrument is not as substantial or dead-beat, and, due to the use of lighter springs, is more apt to be affected by spring fatigue.

It has been found by trial that an instrument of medium resistance (about 300 ohms) can be produced in a satisfactory and substantial form, but an instrument of this class is necessarily affected in its indications when leads of considerable length are employed. Material variations in the length of thermo-couples are also a source of error, as well as the introduction of compensating leads. When compensating leads are employed, as well as long wires, in connecting the thermo-couple with the instrument, it is a common practice to reduce the resistance of the instrument in order to offset the effects of line resistance. This is at best a method of doubtful value, since it interferes with checking the scale by comparison with a standard, and does not compensate for changes in the resistance of the line or thermo-couple, due to variations in temperature.

Various devices and attachments have been made for use in connection with indicating and recording millivoltmeters and pyrometers, by means of which the instruments will remain direct reading, and at the same time be compensated for external or line resistance. Inventions of this class range all the way from a simple step rheostat connected in series with the "dead" resistor of the instrument, to the elaborate and complicated apparatus employing the substitution and deflection methods. Here the potential of the thermo-couple is first balanced against another potential derived from a dry cell; and after an intermediate operation and an intercomparison of deflections, the effect of line resistance is finally balanced out by means of a rheostat, and direct deflections are obtained from the thermo-couple current.

It remained for Paul D. Foote and T. R. Harrison, of the Bureau of Standards, Washington, to offer an invention of theirs, which, incorporated in such a pyrometer, eliminates the effect of line and thermo-couple resistance by means of an operation which is so simple that anybody can use the instrument and obtain accurate results.

In testing with this apparatus all that is necessary is to connect the thermo-couple with the instrument binding posts in the usual manner, press a button, turn a knob and take a reading, which will be the correct e.m.f. of the thermo-couple at its hot end, even if the line is miles in length. In fact, the line may have as much as 15 ohms resistance.

For those who would like to understand the fundamental principle of the Harrison-Foote invention, and at the same time prefer a simple demonstration, the following explanation should be of interest; especially since it reduces the method to its most elemental form, by substituting an ammeter in place of a pyrometer and using cells instead of a thermo-couple.

If *A* (Fig. 2) is an ammeter of negligible resistance, in series with three resistors of 11, 8 and 11 ohms respectively, and an e.m.f. of 6 volts is impressed by a battery, also of negligible resistance, it is evident that the resistance in circuit will be 11+8+11=30 ohms, and by Ohms' law (C=E/R) the current throughout the circuit will be 6/30=0.2 ampere, and the ammeter will indicate accordingly.

If now (Fig. 3) a plug is inserted in *P*, the resistor R_2 will be short circuited. By the same operation, the resistor R_4, which also has a resistance of 8 ohms, will shunt or "by-pass" the ammeter, thereby robbing it of part of its current. In other words, the current splits when it reaches the plug, part of it going through R_3 and the ammeter, and the remainder through R_4, re-uniting at *p* and passing through R_1, back to the battery.

The total current in this case will, of course, depend upon the total resistance in circuit. Since R_2 is cut out the resistance will be R_1=11 ohms,+R_3 and R_4 in parallel. By the law of divided circuits, the resistance of R_3 and R_4 will be their product divided by their sum, or (8×8)÷(8+8)=4 ohms. The total resistance is then 15 ohms and the current 6/15=0.4 ampere, twice the current flowing in Fig. 2.

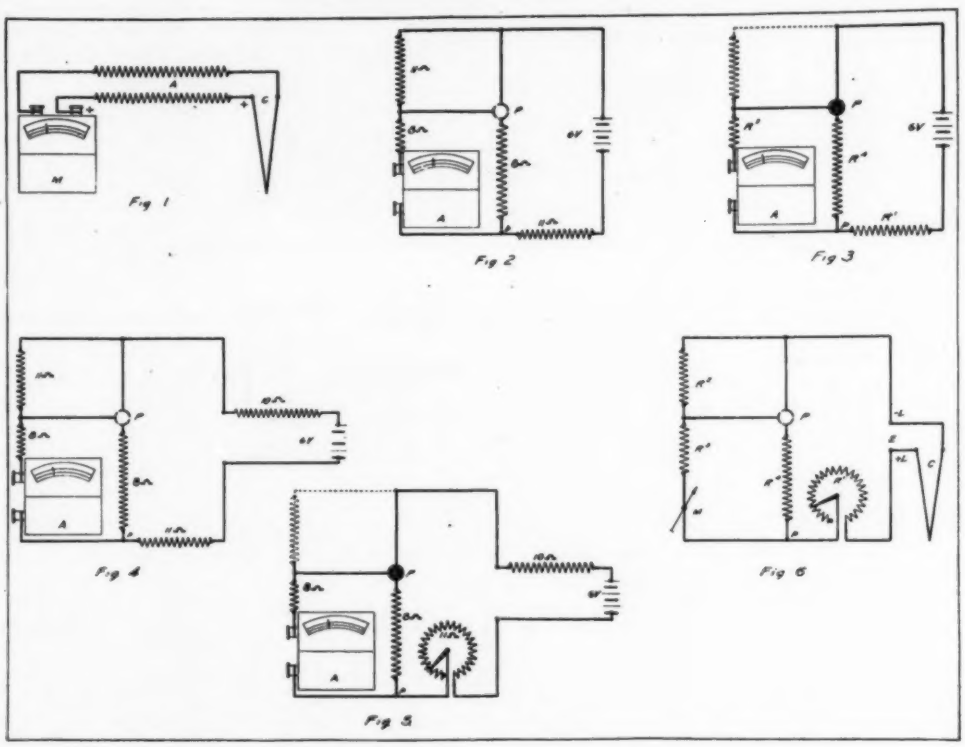
But it is obvious that, since R_3 and R_4 are alike in resistance, the current in splitting at *P* will divide evenly, half of it passing through the ammeter. Therefore the ammeter will indicate only one-half of the total current or 0.2 ampere, the same as in Fig. 2. Hence, under these conditions the deflection of the ammeter will not be changed whether the plug is in or out. If, however, 10 ohms of line resistance is added to the circuit (see Fig. 4) the current with plug out will be 6÷(11+8+11+10)=0.15 ampere. With plug in, R_2 is cut out as before, and the total resistance will be 10+11+(8×8) ÷ (8+8=25 ohms and the current will be 6/25=0.24 ampere.

Of this current, one-half or 0.12 ampere will pass through the ammeter. Its deflection will hence be less than in Fig. 2 when the plug is inserted, and the ammeter pointer will move down scale. To remedy this, let R_1 be in the form of a rheostat (Fig. 5). Then if the resistance of this rheostat is reduced an amount equivalent to the 10 ohms of line resistance, the conditions prevailing in Figs. 2 and 3 will be re-established, the line resistance will be compensated for, and the pointer will again indicate 0.2 ampere, with plug in or out; all of which is very simple and self evident after it has been demonstrated and explained.

In the actual construction of the instrument for technical and practical use, the movable system consists of a highly sensitive copper or aluminum wire coil suitably mounted in an intense magnetic field. In place of the plug *P*, a three-way press button is used. The shunt R_4 need not, of course, have a resistance equal to that of R_3, in fact it is preferable so to proportion it that the current through the circuit as a whole may be increased eight to ten times. The deviation of the pointer from normal will hence be large for even a very slight change in line resistance permitting easy adjustment.

In practice the rheostat R_1 has a resistance of 15 ohms, subdivided into steps of approximately .05 ohm,

(*Continued on page* 383)



Effect of line and thermo-couple resistance

Keeping Fire Apparatus Efficient

The Repair, Manufacturing and Test Work of the New York Fire Department Repair Shops

By Herbert T. Wade

In no form of activity is preparedness a more vital consideration than in the ordinary routine and maintenance of a municipal fire department. In every large city the fire department is on duty twenty-four hours a day, three hundred and sixty-five days in the year, and men and apparatus at all times must be ready to function with 100 per cent. efficiency. Even if there is adequate and available apparatus, there are times in actual service that it must be pushed even beyond its full capacity, irrespective of damage or lack of economy in operation, and with resulting injury. Furthermore, the mobility of fire apparatus involves not only convenience and speed in reaching a fire, but also danger from breakage in such rapid trips, in addition to the ordinary hazards of crowded city streets and bad pavements. At the fire itself it may be operated at overload, damaged by falling walls, or exposed to ice, or even flames in the case of aerial ladders. Consequently the repair problem is a serious one for a fire department, and its facilities in this direction are in constant demand and often over-taxed.

This, indeed, is the case with the well equipped and organized repair shops of the New York Fire Department, which in addition to making special repairs possesses other and important functions. Not only is damaged or worn apparatus repaired, but the ordinary equipment is kept in shape by this organization and its personnel, while all new apparatus must undergo careful and practical tests in order to ascertain whether it complies with the specifications under which it is purchased and whether it is suitable for service. Such tests are indeed a most serious matter, for failure in fire apparatus at a time of emergency such as a large conflagration may be most disastrous, and the possible breaking down of pumps or motors, or the bursting of hose are not to be lightly regarded, and must be safeguarded against by every means possible. In this connection the technical staff of the repair shop is called upon to assist in the formulation of specifications for the purchase of new apparatus, and they can do this with special intelligence, as its organization comprises officers of the uniformed force, who have had practical experience in fire fighting with all types of apparatus. Finally, at the New York Fire Department Repair Shops there is the matter of the manufacture of special supplies and appliances, which can be made better in a departmental shop than by outside contractors or purchased in the market.

It must be borne in mind that within the last ten years there have been radical changes and important developments in fire apparatus. The passing from horse drawn apparatus to motor equipment has been no less striking than the transition from the hand drawn and manual power pumps to the horse drawn steam machines of the past century, and there has also been involved the change from steam to gasoline engines, both for propulsion and for operating the pumps. In many large departments, including that of New York, the transition has been gradual, and to existing steam fire engines some form of tractor device has been fitted. This has been done to utilize the pumping equipment in the form of steam engines on hand, whose functions have been well understood by firemen, and whose reliability has been demonstrated in years of service.

With gasoline propelled vehicles comprising a powerful gasoline motor geared to the wheels, it was of course simply a mechanical problem to supply pumping machinery that could be geared or connected to the main engine when the latter was disengaged from the propelling machinery. At first such combination pumping engines were far from reliable, and the experimental stages were indeed prolonged over several years, but to-day motor apparatus is highly developed, efficient and reliable, and while it is not fair to say that it is susceptible of no improvement, nevertheless it stands on a reasonably satisfactory basis.

Of course the day of horse drawn apparatus long since has passed, and it is only maintained until a suitable motor equipment can be provided, or under exceptional circumstances. In fact, in the city of New York there are 128 motorized engine companies and but 48 remaining to be motorized. With a spare engine required for every sixth company, there would be 8 additional engine companies, or a total of 56 engines to be motorized. In addition, there are 7 hose companies, which will have to be equipped with engines on account of increasing conditions of service, so that to-day a total of 63 new engines are required for the city of New York in order to bring its service up to a reasonable standard. Likewise there are 83 motorized truck companies in the city and 28 to be motorized, 12 of which must be city service trucks, and there must be allowed one spare for every sixth piece of apparatus, making a total of 32 trucks required. Further, 4 engine companies now are awaiting motor hose wagons.

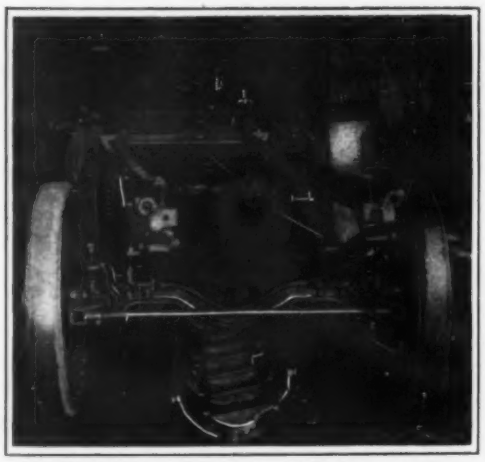
These statistics are of interest in connection with the repair shop, not only as stating the requirements of the New York City Fire Department, but as indicating the amount of repairs necessary, as any one with automobile experience realizes that motor equipment is subject to various mishaps, and requires more or less attendance in the garage or in the machine shop, ranging all the way from actual repairs and rebuilding to minor adjustments, so that in the fire department the repair shop mechanic has to take the place of the veterinary, and the apparatus must be properly inspected and maintained in good condition for service.

Consequently the repair shop organization, under Chief Richard J. Marshall, with Chief James Henry, who is in special charge of the motor work and the motor instruction of the firemen, carries on a regular inspection of the motor apparatus in the various fire houses. In addition to passing on questions of operation, replacements and repair, officers of the repair shops attend large fires day and night where repairs may be required, and an emergency crew is always ready for service.

The repair shop, as already noted, has an important function in the testing of apparatus for acceptance, and it may be said that within a year and a half, 15 pumping engines, involving a value of $150,000, were rejected as not meeting the specifications. As demonstrating the correctness of this rejection, one of these pumping engines was sold to an adjoining city, and within a short time, according to published statements in the local press, proved a distinct failure in actual service. Likewise in the same period 5 ladder trucks of some $50,000 value were also rejected as not complying with specifications, but later, owing to the extraordinary demands for apparatus and the war emergency, several of these were purchased in the open market. As the aerial ladders are employed in removing occupants from burning buildings whose escape is otherwise cut off, their strength and efficiency must be shown beyond question.

The testing of hose is also an important function of the repair shops, and here, as for other equipment and appliances, rigorous specifications are drawn appropriate to the needs of the city, and exceeding the requirements

Store room containing some 10,000 different articles and tools



Motor apparatus disassembled for repairs

A demonstration of engine operation by the chief of the motor school

Replacing a rebuilt engine on the chassis of a motor hose wagon

in many cases set by the National Board of Fire Underwriters. Hose to be accepted by the city of New York under the present specifications must undergo a laboratory test, involving physical and chemical tests of the material and a determination of its ingredients. It receives a hydraulic test of 400 pounds pressure, 20 per cent. of the hose taken at random being actually tested at this amount. The hose supplied is double jacketed hose, and after the outer jacket is removed, the inner jacket is tested at 400 pounds pressure. One length in each lot is tested at 600 pounds pressure. There is also a test for twisting and elongation. The testing of other supplies is also an important branch of the work, especially those furnished by the vendors of materials where rigorous compliance with the specifications is required.

From the engineering point of view the most interest probably attaches to the testing for acceptance of motor propelled fire apparatus. This is a matter of great importance, as not only is the city of New York a pioneer in much of this work, but its policy and equipment are looked to by many smaller communities. It must be progressive and carry on a certain amount of experimentation, yet at the same time be conservative. It is obvious that the best types cannot be secured unless certain chances are taken and new forms of machinery tried out in practice. Since motorization was adopted for the New York City Fire Department, some $3,000,000 has been spent on apparatus that frankly may be considered more or less experimental, but the results, whether they have been positive or negative, have been more than compensating, and the New York Fire Department now knows what to secure as well as what to avoid.

To-day all apparatus undergoes a 12-hour test, and a pumping engine rated at 700 gallons capacity must maintain that rate for 4 hours against 125 pounds pump gauge pressure, with the engine not exceeding 1100 revolutions per minute, and not developing excessive heat. Such an engine must develop 400 gallons capacity at 200 pounds pump pressure for 4 hours, 320 gallons at 250 pounds pressure for 2 hours, and 200 gallons at 425 pounds pressure for 1 hour, in the case of a piston pump. These pumping tests are made on a city wharf, which is convenient to the repair shops, located as they are on a marginal street facing the Hudson River.

The road test for motor fire apparatus is no less important, and the specifications demand that a test run of 20 miles shall be accomplished over city streets in traffic in one hour with one mile at a speed of 30 miles an hour, to show the flexibility of the motor. To show hill climbing and braking power, tests are made on a 15 per cent. grade at which a speed of 7 miles an hour must be made. To test the braking power the apparatus fully equipped must be brought to a stop at three points while descending the hill at speed.

There are in the city of New York 184 engines motorized and 84 truck companies, and 20 spare engines, 18 spare hose wagons and 10 spare trucks are held in readiness for breakdowns. As soon as a piece of damaged equipment is removed to the repair shop, its place is taken by a spare machine; and the proper adjustment of repairs and the providing of emergency facilities is an important function of the repair shops.

The city of New York has paid heavily for its motor development, and, as in any new stage of mechanical engineering, there have been varying degrees of efficiency in the different appliances acquired. Under a system of public bidding, it was found that many assembled machines could be turned over to the city, and these, while furnished cheaper, often increased the maintenance cost, as extra parts were difficult and sometimes impossible to procure. To-day the New York City specifications require that a manufacturer must make his own motor, must have 50 pieces of like type in service, and must be so established that the various parts can be secured from service stations within reasonable distance.

These considerations of specifications and tests are interesting in connection with the Repair Shop, to which damaged or defective apparatus naturally returns. The Repair Shop must replace injured parts, irrespective of whether they can be secured from manufacturers or must be developed and made within the shops themselves. Accordingly one important feature of the shops has been the improvement of various features of the motor apparatus in connection with necessary repairs, sometimes involving the re-design and re-making of the motors themselves, and at times the actual construction of an improved motor when failure takes place. Experience showed, for example, in one case that three sets of ball bearings for a crank shaft were preferable to one set of balls and two sets of babbitted bearings, and this modification was adopted for rebuilding engines as required. The shop, with such important replacements and repairs in addition to minor work, accordingly has its designing room, a pattern shop, where the wooden patterns are made, a machine shop, finishing and assembly departments. There is a foundry for brass and aluminum, as well as a forge room, but the larger castings, as for engines, are made outside. The machine shop and assembly rooms possess the most interesting mechanical features of the repair department, and excellent work is done, which is constantly being improved. In this way it has been possible to improve greatly much of the motor apparatus that has been acquired by the department which in some cases began to show wear or failure of parts at as little as 200 miles.

Of course it is impossible at this present stage of development of motor apparatus to standardize everything, but standard apparatus is the aim of the New York Fire Department, and standardized axles and wheels are specified and maintained, so that an extra wheel can be fitted at once from the supply of spares in case of an accident.

Closely connected with the motor work is a new battery room and charging board, where batteries for the motor apparatus may be rebuilt instead of being purchased, and a delivery system to the various companies has been arranged so that battery troubles can be remedied at an early moment and charged batteries sent out at short notice.

In an adjoining department are the leather shops, where the tops and upholstery of the motor vehicles are now made, and such harness as is in use is repaired, no new harness being purchased.

The wheel shop, several illustrations of which are shown herewith, is an interesting portion of the Repair Shop, as naturally repairs to wheels and the construction of new wheels is an important part of the work, for extra wheels must be maintained and damaged wheels must be replaced. The repairs may involve new spokes, felloes, hubs, new metal rims or rubber tires. The test of rubber tires is also an important consideration, for this is a large item of equipment and maintenance, whether on the heavy trucks and pumping engines or on the official cars.

The Wheel Shop. Rebuilding a damaged wheel. Preparing the spokes to receive the felloes

Making the spare wheels ready. Here a rubber tire is being set on a standard wheel

While fire apparatus in appearance has sobered down somewhat from the older days, nevertheless the ornamentation, involving painting, varnishing and nickel-plating, still is quite a characteristic, and consequently the paint shop, where repaired apparatus receives its vermilion coats, and the varnish shop, with heat adjustable to a constant temperature, are of interest. Then there is the nickel-plating shop, where various parts are nickel plated, not merely for ornamentation, as the nickel plating is essential in view of conditions of weather and exposure. This involves not merely the small parts but even the domes of the engines.

In the carpenter shop, situated on the upper floor of the Repair Shop, there is a pattern room, and ladders, both extension and scaling, are made and repaired. Considerable trouble has been experienced in securing straight Oregon pine for ladders, but the stock on hand is carefully kept and seasoned. All ladders for replacements and repairs are made here, though the new trucks are purchased fully equipped.

The test and repair of hose naturally involves special machinery and appliances, and our frontispiece shows where a hose coupling is being expanded on the end of a length of hose by hydraulic pressure and the use of a special machine.

Another of our illustrations shows the stores department, where are kept some 10,000 articles available for issue and for minor repairs, many of which are done as well as the more important work.

In examining the new apparatus at the Repair Shop submitted for test or for minor repairs, it was interesting to observe that the city of New York is purchasing no more steam engines, and that motorized pumping engines are now satisfactory for all purposes, and especially with the independent high pressure fire service maintained by New York in congested or high risk territory. Good equipment is now manufactured, and the writer's attention was called to 8 engines of a certain standard type made by a single company that had been in use for 4 years each, and where the total repairs for all had not exceeded $800. It was pointed out that the manufacturers of American fire apparatus have now reached a point where they are able to deliver efficient and practical machines that will stand up under the work, and the best apparatus is now supplied by companies that have specialized in this field with engineering staffs specially devoted to such machinery, and with the close cooperation of fire engineers from various cities. The better class of material that has been reduced to standard types and practice and made by companies that specialize in fire department needs does not occasion the Repair Shop the trouble caused by the assembled apparatus or experimental types that are able just to meet minimum requirements.

The Repair Shop is also the location of the motor instruction school, where firemen are trained to understand engines and handle motor apparatus, as well as make minor repairs and adjustments under the direction of Chief Henry.

It might be truthfully said that the Repair Shops of the New York Fire Department are a national laboratory of fire appliances, where new apparatus is tested and where service is studied. Much credit for this work is due to Chief John Kenlon, who is the head of the New York Fire Department.

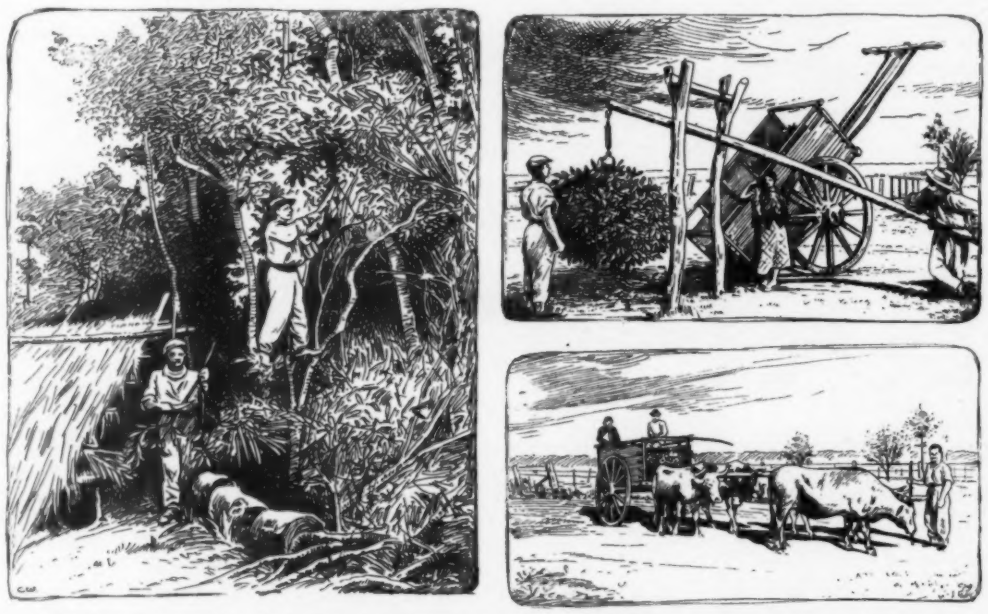
Scented Soap from Paraguay Oranges*

The Bitter Fruit whose Leaves Form the Basis of Most of the Perfumes Employed

By Edward Albes

Of the multitude of fastidious ladies of fashion in the United States—or elsewhere for that matter—whose olfactory nerves are agreeably titillated by the delicate perfume of the scented toilet soap they use, how many know that the chances are that they owe this particular gratification to an essence commercially known as the oil of petit grain? And furthermore, how many of them would be likely to know that this essence was probably born in the far-away Republic of Paraguay? Perhaps not one in ten thousand. The fact is, however, that the basis of these delicious odors is oftener than not the product of that country, for Paraguay is said to furnish about 70 per cent. of the world's supply of this valuable adjunct to the perfumer's art. Incidentally, the commercial name itself would perhaps mean little to the average society belle. In fact, she might not take kindly to the idea that an oil of any kind had anything to do with her favorite perfume or the sweet-scented Florida water she delights in; but if told that this oil is really the essence of the leaves of an orange tree the information would doubtless be more agreeable.

While distilled perfumes of various kinds are almost as old as human vanity, there are some that are of more modern invention and among these is the product which forms the subject of this little sketch. Its name, "essence de petit grain," was given it by the French because once upon a time an oil was distilled from the rind of the small fruit of the bitter orange tree. This was really an essence of "small fruit," and the name stuck even after the substance was derived from a somewhat different source. It was made chiefly in the extreme southern sections of Europe, especially in southern Spain where the bitter orange (botanically known as citrus aurantium, var. amara), introduced in Andalusia by the Moorish conquerors, thrived and was extensively cultivated. There, too, from the buds and flowers of both the bitter and sweet orange was distilled a volatile oil known as oleum neroli, much used as a base for various perfumes by the manufacturers for many years. The cost of production of this essence of the delicate flowers of the orange tree was considerable, however, and just how a small country in the interior of South America came to dominate this industry is a more or less interesting story to be briefly outlined in the following paragraphs.



Gathering and weighing the leaves of the bitter-orange tree, and hauling a load of them to the factory

In the first place, Paraguay is preeminently the land of the orange tree. In fact it may be called a wild garden of citrus trees of many varieties. About a quarter of a century ago Dr. E. de Bourgade la Dardye, a French gentleman of culture and scientific attainments, after living in that country for over two years wrote an excellent little book which dealt with the people, the land, and its natural wealth, its commercial possibilities, etc. The last chapter of the volume deals with the country's wealth of orange and other citrus trees, and the following excerpts will give the reader some idea of the natural conditions which led to Paraguay's dominance of the oil of petit grain market:

"Everywhere, on the banks of the rios, in the gorges of the far-off sierras, near the ranchos, round the estancias, in the solitude of the forests, the trees are seen with their golden fruit and deep-green foliage, in lines, in terraces, in groves—everywhere, on mountains and on plains, they grow and break the blue horizon with their rounded outline—and it seems as if they must have flourished there from all antiquity.

"I am quite ready to admit that the sweet orange, the bitter orange, the lemon, and their numerous varieties were imported either by the Spaniards or by the Jesuits; of this there can be little question; the original habitat of them all was in Asia, and the history of their dissemination is well known; but at the same time there is a Paraguayan orange specially belonging to itself. It has a flavor that is slightly acid, which makes it very acceptable in hot weather; without cloying the palate like the sweet orange, or setting the teeth on edge like a lemon, it seems to cleanse the mouth in a way that is very refreshing. So far from growing everywhere, it is found chiefly in the depths of the forests and on the banks of insignificant streams. I have met with it in the most remote places, in the unexplored valleys of the Ygatimi, and on the margin of the Upper Parana, where it could certainly never have been introduced by human agency. So abundantly does it grow on the Parana above the Salto de Guayra that during a flood I have seen numbers of the trees drifting down the stream. . . .

"But, after all, whether oranges of any kind are indigenous to Paraguay or not, it is very certain that they well might be, for the whole world could not show a soil that is more favorable for their growth. Without attempting to enumerate all the varieties of oranges and lemons that are found, I may mention the following as being the most common: The sweet orange (citrus aurantium), the bitter orange or bigarrade (c. bigaradia), the mandarin orange, the apepu; the citron (c. medica), the toronjo (c. limonium citratus), the common lemon (c. limonium), the lime or sweet lemon (c. limetta), and the lime of Persia.

"It would be quite impossible to form a true estimate as to what extent of area in Paraguay is taken up by this orange growth. Sometimes singly, sometimes in clumps, sometimes in vast forests—as in part of the Missions—the trees thrive in almost every district, here under cultivation, there entirely wild."

Now, it was into the midst of this profusion of budding, blooming, and fruiting orange trees of many kinds that in 1873 a man by the name of Balanza was plunged. He, too, was a Frenchman, a botanist, who had gone there for the purpose of studying the flora of the country, and when he saw the millions of sweet-scented blooms that were being allowed to wither and die without the slightest effort being made to put them to profitable use, the thought came to him that here was an opportunity to develop a new industry in this remote and little-known section of the world. The world stood ready to exchange its gold for the delicious fragrance that here was being wasted "on the desert air." He forthwith discarded his herbalist's case, procured an ordinary serpentine still, and transformed himself from an ardent devotee of science into a prosaic manufacturer of perfume.

With his primitive but very practical distilling apparatus M. Balanza successfully produced from the orange flowers an essence, the oleum neroli, of very superior quality. He soon found, however, that there were serious difficulties in the way of manufacturing the product in sufficiently large quantities to be profitable. In addition to the oleum it seems that he was desirous of producing distilled orange-flower water, and in this, too, he found the same handicap.

In order to obtain an essence with the full maximum of perfume, it is necessary that the blossoms be gathered just as the petals are opening and disclosing the heart of the corolla. In the planted orange groves of southern Europe this is practicable; there in the spring the buds of the trees usually open at about the same time. As soon as the petals are unfolded they can all be shaken at once into cloths that have been spread underneath to catch them, and can thus be collected without being touched by the hand, which deprives them of a portion of their fragrance. But in Paraguay such a method was found impracticable. The bitter oranges grow so closely together in the forests that the blooming comes on very irregularly, and unopened buds, full blossoms, withered flowers, and forming fruit are often found on the same tree. The blossoms had to be collected by hand, thus increasing the labor cost and materially deteriorating the delicate petals. The only way to overcome this handicap is to plant and cultivate the bitter-orange trees, so spaced that the vegetation of each tree is left unchecked.

Finding this obstacle too great to be overcome by the means at his command, M. Balanza proceeded to make experiments with the leaves of the bitter-orange trees. He found that the essence produced was an excellent substitute for the oleum neroli, having practically identical properties, and with a superabundance of leaves easily and cheaply gathered and his simple distilling apparatus he started the industry which has now grown to considerable proportions. Even to this day very little improvement over the Balanza equipment has been made and the factories which supply the greater part of the world's demand for oil of petit grain are about as simple as was his. The chief requirements are a little stream of clear water, a primitive palm-thatched shelter for a simple furnace fed by wood picked up or cut in the immediate vicinity, a large vat covered by a cap from which leads a pipe or tube coiled in a cooling chamber where the condensed vapor is caught. The vat is filled with the leaves and the steam is forced through holes bored in the bottom of the vat, the pressure being no greater than one atmosphere. The vapor, saturated with the volatile oil of the leaves, is condensed in the receiving receptacle, the oil skimmed off, and there is the product. In this form it is considered ready for the market by most of the producers, but it has a distinctly oily odor. Large producers now have a secret process of distillation that further refines the essence and leaves it with a perfume like that of the familiar Florida water, of which it is the base.

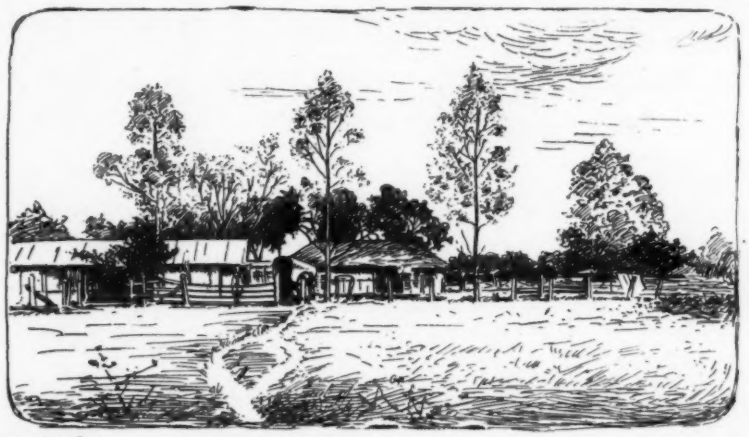
From 500 to 600 pounds of the bitter-orange leaves will produce about one quart of the ordinary oil of petit grain. The cost of the leaves is not great and the profit large. An average size still will produce about 4 quarts a day. There are between 30 and 40 factories operating in Paraguay, the majority being located at Yaguaron, owing to the great number of bitter-orange trees growing in that vicinity. Other places having factories are Ita, San Jose de la Cordillera, Itacuruby, and Nemby. The price of the product delivered at Asuncion ranges from $6 to $7 per kilogram, or from $2.73 to $3.20 per pound, in normal times.

Practically all of the output of the oil of petit grain from the Paraguayan factories is exported, and the industry is gradually increasing in extent. In 1913, the last normal year prior to the European war, the total exports amounted to 71,322 pounds, of which France took 23 400 pounds; Argentina, 25,743 pounds; Italy, 8,378 pounds; Austria-Hungary, 7,430 pounds; and Germany, 5,137

* From the *Pan American Union*.

pounds. The United States took 16,821 pounds, most of which was reexported from Argentina. In 1914 the declared exports of the product from Paraguay to the United States, according to the records of the American consulate at Asuncion, reached a value of $20,835; in 1915 the amount exported to the United States was 23,040 pounds, valued at $35,416; in 1916, 33,680 pounds, valued at $60,496; in 1917, according to Paraguayan statistics, the total amount exported was 61,498 kilograms, valued at 215,243 pesos gold, which being translated into United States units means about 135,300 pounds, valued at $208,765, and of this amount the exports to the United States, according to the consular report, reached the value of $113,742, thus showing that since the war the United States has become Paraguay's best customer for this sweet-scented product.

Incidentally, it may be added that while the oil of petit grain is distilled from the leaves of the bitter-orange tree, the fruit is a valuable product as well. Besides the oxalic and citric acids extracted from the pulp, the peel furnishes several medicinal sirups, is made into marmalade, and forms the main ingredient in the well-known liqueur called curaçao. When the trees have ceased to be prolific the wood is utilized by cabinet-makers, who pay good prices for it.



A typical Paraguayan "oil of petit grain" factory, and a branch of the bitter-orange tree from which this essence is distilled

The Behavior of Land Insects with Regard to Water*

By J. S. Szymanski

MANY localities inhabited by insects are frequently flooded since after every heavy downpour numerous pools containing small islands are to be found in the fields and meadows. It seemed a matter of interest to investigate how the insects found on such islands manage to rescue themselves from the water and take refuge on "land." Almost fifty kinds of insects were examined with respect to this question. The method of study was extremely simple, consisting of placing the insect to be examined on a small wooden bridge provided with two ladders. The bridge was so placed in a dish filled with lukewarm water that it extended above the surface of the water while both ladders reached to the bottom of the vessel. The depth of the water in the vessel varied from 4 to 15 cm. according to the size of the insect being tested.

The insects placed upon the bridge behaved in one of four different manners, as follows:

I. Flying or jumping insects left the bridge either by flight or by springing across the surface of the water (the meat fly *Sarcophaga*, and the small cricket, *Triecphora*). These insects do not go beneath the surface of the water of their own accord. The light and quickly moving insects (*Cantharis*), apparently *Fusca*, the *Malachius rubidus*, and the *Anoncodina austriaca*, which are not able to take flight except from an elevated point, run rapidly back and forth upon the bridge till they fall by chance into the water, where they kick their legs convulsively but finally remain motionless on the surface of the water. Apparently these kinds of insects can only escape from flooded territory by flying away.

II. Land insects which are good swimmers, throw themselves into the water of their own accord and swim to land (the "horse ant," *camponotus—Sp.*, the ground beetle, *Caradus—Sp.*, two different *Harpalus—Sp.*, and the *Pterostychus—Sp.*).

III. One sort of spider (*Lycosa chelata Mueller*) ran rapidly up and down the bridge but very soon passed on to the surface of the water, on which it is able to run rapidly and skillfully like the water flea. When prevented from reaching the land it drew up its legs and remained lying motionless upon the surface of the water. When it was placed again upon the bridge while in this condition, it would not enter the water again spontaneously. Other kinds of spiders (*Philodromus Aureolus* Oliv.) are able neither to stand nor to run upon the water; still other kinds (apparently the *Dysdera—Sp.*) are able to stand upon the water but scarcely to run upon it so far as I was able to tell.

IV. Heavy and slow moving insects and those which are only heavy or which are not able to fly go to the water of their own accord, usually crawling down the ladder till they reach the bottom of the vessel where they attempt to make their way to land (Ladybirds *Lina popili, Orina—Sp., Priolus—Sp., Geotrupes—Sp., Cetonia aurata*, Grünrüszler; *Phyllobius—Sp., the Abax—Sp., the Galleruca Tanaceti*, etc.); also in many cases the "horse ants."

These insects first carefully investigate the entire bridge; thereupon they make an attempt to enter the water but change their minds and draw back, repeating this a number of times. Finally, after many attempts in the course of which they have become very wet they plunge beneath the surface. This behavior indicates that the increasing wetness of the body serves as an adequate stimulus to incite them to dive. This opinion is strengthened by the observation that almost every example of the different kinds of insects whch I investigated spontaneously crawled down a stick extending into the water until it was beneath the surface provided it and the stick had previously been dipped under water one or more times.

The observation of the manner in which insects save themselves from flooded territory brings out clearly the interdependence between behavior and the organic means at their disposal. The jumping or flying insects make use of these capacities. The insects which swim well (a fact which is often indicated by the flatness and lightness of their bodies) and likewise the insects which walk on water, throw themselves spontaneously upon the surface of the water and make rowing or running motions. Finally, the clumsy, heavy insects, with bodies more or less spherical in shape (*Chrysomelidae*, lady-bird, *Cetonia*, etc.) make used of their superior weight (which enables them to overcome the surface tension of the water) and of their ability to draw themselves up compactly, together with the well-known power possessed by many insects of living under water for a considerable length of time, in order to dive and crawl along the bottom till they reach land. These facts indicate that the manner of the behavior is conditioned by the means of operation which the organism possesses.

THE SWIMMING REFLEX OF INSECTS

The swimming mechanism of the "horse ants" is quite a complicated process which consists of a series of separate reflexes. The swimming ants, which are able to float upon the surface of water because of their low specific weight, keep the head and antennae above water; the fore-legs are directed forward and execute very rapid movements in a sagittal plane. The middle pair of legs are straddled outwards and move in an approximately horizontal plane in a much slower tempo than the first pair of legs. The hind legs, which are held stretched out behind, remain motionless when the ant is swimming in a straight line. When the creature wishes to make a turn it moves the leg which is opposite to the direction of the turn in a horizontal plane, i.e., it rows with the left leg when it wishes to turn to the right and vice versa, the companion leg remaining motionless. This behavior shows that the hind legs assume the steering function.

In order to determine the relative importance of the different pairs of legs in the act of swimming, they were amputated respectively in different individuals. It was found that the amputation of the foreleg causes no disturbance in equilibrium but causes slow and unskilful swimming. The amputation of the middle pair of legs also fails to disturb the equilibrium; in this case the swimming is slow but not unskilful. The amputation of the hind legs influences neither the equilibrium nor the skill shown, merely retarding the swimming somewhat. When turns are made the middle legs exercise the steering function.

These amputation tests indicate finally that the amputation of the forelegs exerts the strongest influence on the act of swimming, while that of the hind legs causes the least disturbance. The amputation of all three pairs of legs in the same individual does not prevent the swimming of the body upon its back upon the surface of the water.

The other kinds or ants (*Formica fusca*, other *F.—Sp.*, *Myrmica—Sp.*) make the same swimming motions but without as much success as the *Camponatus*.

The ground beetles execute rowing motions with the legs in the same serial order as when moving upon the ground; they steer with the hind leg just as the ant described above does. In the *Harpalus—Sp.* it may be often observed that the leg which lies on the same side as the desired turn is drawn out of the water and held in the air until the turn has been made.

Besides these insects I have seen only the tree bugs, *Syromastes* and *Pentatoma*, executing synchronous rolling movements with both hind legs; however, they make very little headway from the spot.[1] All the other kinds of insects investigated by me which do not enter the water of their own accord, when placed in it by me merely made convulsive kicking motions with the legs.

* Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from the *Biologisches Zentralblatt* (Leipzig).

[1] Still another kind of swimming has been kindly brought to my attention by Herr A. Handlirsch of the K. K. Naturhist. Hofmuseum. This authority tells me that some of the small *Ichneumonidae* use the wings for steering when swimming.

Disadvantages of the Use of Protective Fittings of High Candle-power Incandescent Electric Lamps.

IT is usual in many cases to enclose metal filament lamps of high candle-power, used for street-lighting, etc., in closed fittings so as to protect them from rough weather. Experience has shown this method to be disadvantageous. *Inter alia*, the candle-power of the lamps decreases very quickly and the lamp soon becomes defective.

A Swedish engineer, investigating the matter, has found that it is the rise in temperature which causes the rapid diminution in lumious intensity. He ran several incandescent lamps at temperatures of 200° and 20° C., while others cooled by a water-circulation device, were only at a temperature of 2° or 3° C.

After some hours' running, in the case of the lamps at a temperature of 200° C., the luminous intensity had dropped considerably, and they were unusable after 40 hours' running, whereas with the lamps run at 20° and 3° C., the diminution of intensity was inappreciable after this period. This is explained by the fact that at high temperature the glass of the bulb becomes porous and air enters the bulb. This also explains why, where a large number of lamps are arranged close together in advertisement signs, etc., they rapidly deteriorate. (Abstracted by *The Technical Review* from *L'Industrie Electrique*, Oct. 10, 1919.)

A New Compensated Heatmeter

(*Concluded from page 379*)

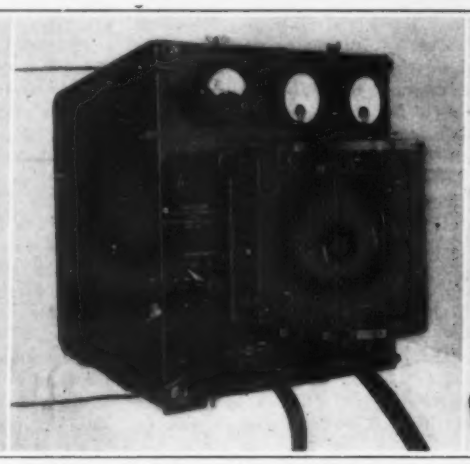
so that the position of the pointer may be regulated with absolute exactness. In this connection, it is in order to call attention to the fact that, while it is, of course, desirable to know what the range of the rheostat is, it is not at all necessary to know or attempt to determine what the line resistance may be. The rheostat is normally set at zero, and in testing for line resistance, is given a clockwise motion. In an experimental model the following proportions were adopted with excellent results (see Fig. 6):

Total resistance for 40 millivolts, 290 ohms.
Current without plug, .000138 ampere.
Current with plug, .00106 ampere.
Resistance of shunt, 26.25 ohms.
Movable system, 53.3 ohms, copper wire coil.
Rheostat, 15 ohms.

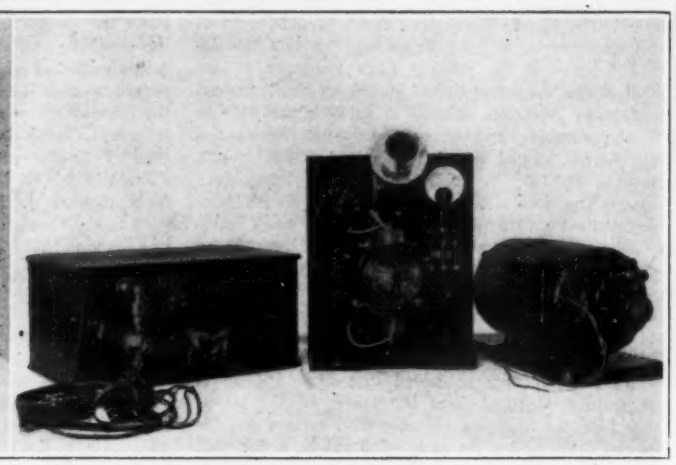
The temperature coefficient of the instrument was +.000365° Fahr. It is, of course, possible to construct these heatmeters with much higher resistances to meet special requirements, but excessively high values in ohms per millivolt are not factors of first importance in this type of pyrometer.

As already stated the shunt R_4 need not have a resistance equal to that of R_3.

Vacuum-tube generator of undamped oscillations, especially suited to laboratory work



Commercial form of vacuum-tube generator. The tube is protected by the heavy wire guard



Simple wireless telephone outfit consisting of a vacuum-tube receiving set, telephone and oscillating-tube unit and motor-generator

Experimental Wireless Telegraphy and Telephony—XII*

How to Become an Amateur Radio Operator and Enjoy This Hobby to the Utmost

By Louis Gerard Pacent and Austin C. Lescarboura

BUYING a piano is only half the problem of getting music into one's home; for one must still master the art of playing that piano. Buying an automobile is perhaps three-quarters or even seven-eighths of the problem of rapid and comfortable transportation; but one must learn how to drive and care for that automobile. And purchasing or building one's radio equipment is only part of the problem of radio as a hobby, albeit an important part; but there still remains the task of mastering the operation of that equipment, and training the ear and mind to respond to that musical language of dots and dashes and spaces known as telegraphy.

MASTERING THE WIRELESS CODE

There is no short cut to mastering the telegraph code. It is a matter of more or less practice, depending on one's adaptability. Some persons can become fair operators in the short space of six weeks, but it generally requires three or four months, and often six, before the average person can receive messages at commercial speeds.

There are two ways of mastering telegraphy, namely, to attend a regular telegraph school, such as may be found in almost any sizable city, or to study it at home. The main advantage of a telegraph school is that the student must put in so many days or nights a week at steady practice, and it is that steady practice that soon results in proficiency. Otherwise, one can study at home, especially if one will devote a certain part of each day to telegraphy.

The first step in a self-instruction course in telegraphy is to learn the code. Up till several years ago the Morse code, which is the code used for our telegraph systems, was used in American wireless practice, although certain ships calling in American waters employed the Continental or European code. Today practically all radio traffic in the United States and most other countries is in Continental. The Morse code is perhaps faster than the Continental, because it has less dashes in its characters, but the use of spaces within the characters themselves, let alone the usual spaces between characters, makes it rather confusing at times and does result in errors. For example, "I" in the Morse code is made up of two dots .. while "O" is also two dots, but with a space between, thus . ., while in the Continental code "I" is two dots .. as in the Morse code and "O" consists of three dashes ———, so that there can be no confusion. Obviously, the use of so many dashes somewhat slows up the Continental code, but this is more than compensated by its accuracy.

A code chart can be obtained from any store handling wireless equipment. With the chart in hand, the student should begin to study the various combinations for the corresponding letters, punctuation marks, figures, and so on. One method is to take say five characters or dot-and-dash combinations at a time, memorize them thoroughly, and then go on to the next five, after which the entire first ten are memorized before attempting the following five, and so on. The result is that in one or two evenings the student should memorize the entire list of letters, after which the figures can be memorized, followed by the punctuation, special devices, and so on.

LEARNING TO SEND AND RECEIVE

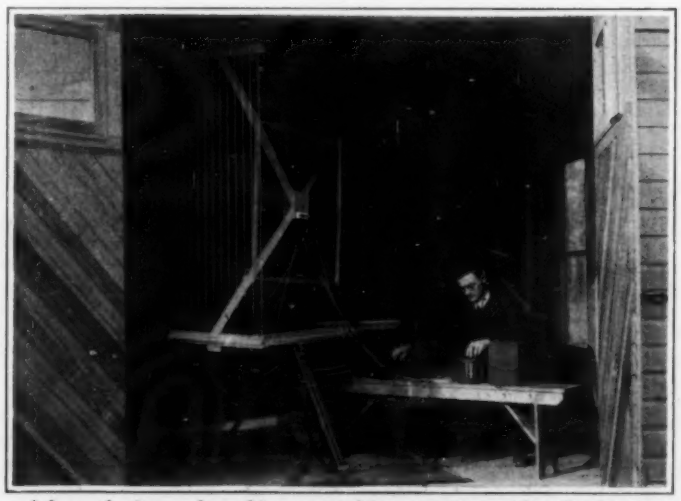
With the code memorized, the next step is to practice sending messages. By means of an ordinary telegraph key, a simple buzzer and a battery, the student can simulate wireless signals with the key. The best form of practice is to take a newspaper or magazine article, and proceed to transmit the words one by one as they are read. At first the sending is slow, but with practice there comes speed, until finally a fair rate of speed is attained. Care should be taken to form the dots and dashes carefully, interposing the proper spacing where there are spaces. If care is exercised at the beginning of such a course, the student will become a good operator instead of a slovenly one. It may be well for the student to obtain a book on telegraphy, inasmuch as many short cuts are pointed out. Indeed, some books have the most ingenious forms of code charts with various characters grouped together according to their telegraphic make-up, so as to hasten the study.

So much for sending; there still remains at least three-quarters of the work of learning to operate, namely, receiving. In the case of a self-instruction course, good results may be obtained by using any one of the several forms of automatic transmitters, which send messages at any desired speed. The messages are sent by means of toothed disks or punched paper tape, which serve to make and break a circuit containing a telegraph sounder or a buzzer, as the case may be. Certain phonographic telegraph courses are also quite satisfactory. Such devices have the much desired quality of transmitting accurate messages at slow speeds at first, and gradually speeding up until the student is proficient.

Another method is to have a friend send messages with a buzzer practice set, similar to the one employed in learning to send. Still another method is to install a wireless receiving set and listen to the commercial and amateur stations. In fact, the Navy is encouraging radio amateurs by sending out an evening code practice. Of course it is somewhat disappointing at first to listen to fast messages without being able to identify more than a letter here and there—and may be not a single letter in an entire message. But that is where the student's patience comes in; he must not be discouraged; he must realize that as in the case of learning a language, it is the constant listening to the code that gradually trains the ear and mind to identify the signals immediately. Six

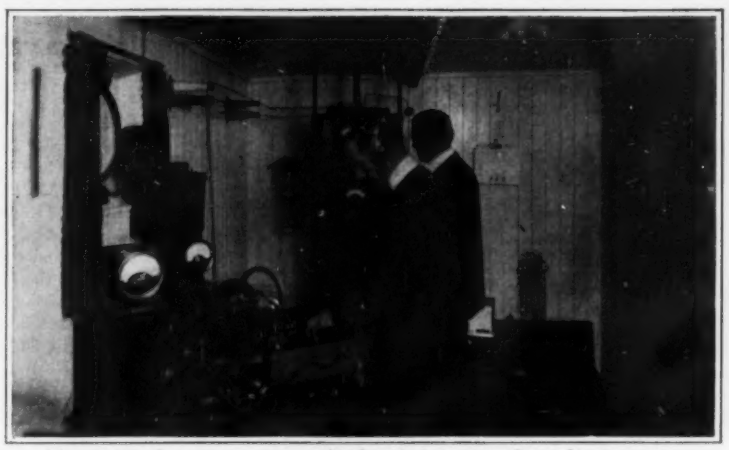
*This is the twelfth and concluding instalment of a series on radio telegraphy and telephony that has appeared at various times in the SCIENTIFIC AMERICAN SUPPLEMENT, beginning with the issue of July 5, 1919, No. 2270. Back numbers containing instalments of this series may be obtained as long as the supply lasts.

In the city the amateur can receive messages by using a gas pipe as the antenna and a water pipe as the ground



A loop of wire, such as this one, used in connection with a three-stage amplifier, enables one to receive trans-Atlantic signals

In order to secure their amateur radio operator's license, these young men are undergoing the examination and test



By means of a wave meter and other instruments the radio inspector tests the stations of amateur and commercial firm alike

months of constant practice should train the average person in receiving at a fair rate of speed.

THE MATTER OF RADIO LICENSE.

In the early days of amateur wireless in the United States there was no Government restriction of any kind. Anyone could purchase a complete wireless set of any power—even ten kilowatts or more if one so desired and one's pocketbook permitted—and operate it in any way whatsoever. The authors have in mind one individual who, having a particular grudge against one of the early wireless companies, proceeded to install a 20-kilowatt set in his home and then began his campaign against wireless traffic in general and his enemy in particular. When that amateur was sending with his 20-kilowatt spark, nothing could be done within a radius of 20 miles or more. His set was tuned in a very broad way, so that his waves could hardly be tuned out by nearby stations. The result was that he seriously embarrassed the company in question.

Such a case, of course, was very unusual, to say the least; yet it served along with other similar instances of radio abuse to bring about some form of radio control, which came in 1912.

The United States wireless regulations have never aimed at suppressing radio; rather, they have been formulated and applied with the object of regulating—or shall we say policing?—the ether, just as the automobile laws aim not at stopping automobiling but rather toward making it safer for pedestrians and riders alike. During our participation in the war, amateur wireless was entirely suspended and the matter placed in the hands of the Navy Department. Shortly after the signing of the armistice which brought hostilities to an end, the ban was lifted on receiving only; and last October 1st all restrictions were removed, allowing amateurs to resume transmitting, provided, as was the case before the war, that they had amateur operating and station licenses.

No license of any kind is required for the amateur who wishes to receive only. For transmitting signals, however, the amateur must apply to the Radio Inspector, Customs House, of the city at which his district office is located. The business of regulating amateur radio is in the hands of the Department of Commerce, which is represented by Radio Inspectors, each of whom is assigned to a certain district. The radio districts and the office for each are as follows:

1. BOSTON, MASS.

Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut.

2. NEW YORK, N. Y.

New York (County of New York, Staten Island, Long Island, and counties on the Hudson River to and including Albany, Rensselaer, and Schenectady) and New Jersey (counties of Bergen, Passaic, Essex, Union, Middlesex, Monmouth, Hudson and Ocean).

3. BALTIMORE, MD.

New Jersey (all counties not included in second district), Pennsylvania (counties of Philadelphia, Delaware, all counties south of the Blue Mountains and Franklin County), Delaware, Maryland, Virginia, District of Columbia.

4. SAVANNAH, GA.

North Carolina, South Carolina, Georgia, Florida, Porto Rico.

5. NEW ORLEANS, LA.

Alabama, Mississippi, Louisiana, Texas, Tennessee, Arkansas, Oklahoma, New Mexico.

6. SAN FRANCISCO, CALIF.

California, Hawaii, Nevada, Utah, Arizona.

7. SEATTLE, WASH.

Oregon, Washington, Alaska, Idaho, Montana, Wyoming.

8. CLEVELAND, OHIO

New York (all counties not included in the second district), Pennsylvania (all counties not included in the third district), West Virginia, Ohio, Michigan (Lower Peninsula).

9. CHICAGO, ILL.

Indiana, Illinois, Wisconsin, Michigan (upper peninsula), Minnesota, Kentucky, Missour, Kansas, Colorado, Iowa, Nebraska, South Dakota, North Dakota.

In writing or calling on the Radio Inspector, the amateur should ask for application blanks for operator's examination, station license, or both, as the case may be. All licenses were revoked at the beginning of our war.

For operating a transmitter two licenses are required—a station license and an operator's license. The station license is issued when the station has been examined and found to conform with the rules and regulations. The matter of wave length is a most important one, and amateur transmitters must be kept below 200 meters. Then again, the emitted waves must be sharply tuned, so that they can be readily tuned out by receiving stations. The degree of this sharpness of tune is defined by the term decrement, which has a very big meaning with the Radio Inspector.

The radio amateur operator's license determines the amateur's operating ability. A transmitting and receiving speed of ten words per minute is considered ample proof that the applicant is worthy of an operator's license, provided said applicant has a good knowledge of wireless equipment, its arrangement, and manipulation. The amateur must be able immediately to recognize S. O. S. or distress calls.

Aside from being limited to 200 meters' wave length, the amateur transmitter cannot exceed 1 kilowatt input. When within five miles of a U. S. Naval or Army station, the transmitter is limited to ½ kilowatt and sharp tuning in all instances must be observed. Radio telephone experimenting also comes under the rules and regulations of the Department of Commerce, as well as any form of apparatus emitting antenna oscillations.

Only the fundamentals of the wireless regulations are given in the foregoing. The amateur is referred to the Radio Inspector in his district for full information.

What more can be said in concluding this series than that there is no hobby in the world that attracts a better class of young men and men than amateur radio. During the war the United States Army and Navy secured thousands of young men trained in radio and possessing an excellent knowledge of electricity, thanks to their years of interest in amateur radio. Many of the former radio amateurs have made their mark in the scientific world, proving that this hobby often leads to greater things.

However all that may be, the fact remains that the amateur is immediately welcomed by other amateurs in his immediate vicinity. A helping hand will always be found when problems have to be solved. And with amateur stations dotting the country from one end to the other, one need never be out of touch with one or more members of the big fraternity of wireless amateurs, such as they are called, for want of a better name.

Electrons and Heat

By Fred. G. Edwards.

If the atomic ether be incompressible and therefore its atomic volume constant, as described in former papers on "Mechanical Philosophy" (Chemical News, 1919, cxviii., 183, 270), it follows that there can be no contraction or expansion of solids without the relative formation of mechanical electrons in the body of the metal or dielectric, and the formation of these electrons will render the adjoining atoms correspondingly positive as required for the scattering of α-rays. There would be a finite number of electrons per cc. in accordance with the temperature, and their reduction or amplification would be identical with the flow of heat.

Prof. Callendar (B. A. Dundee, 1912) asserts "that the corpuscles of caloric which constitute a current of heat in a metal are very closely related to the corpuscles of electricity, and have an equal right to be regarded as constituting a material fluid possessing an objective physical existence." Neglecting the entropy of the ether and assuming that the entropy of a substance is zero at zero temperature, we are also in agreement when he asserts "that entropy was simply Carnot's caloric under another name, and that the increase of entropy in any irreversible process was the most appropriate measure of the quantity of heat generated." Again, Prof. O. W. Richardson found that a platinum wire heated to between 1020° and 1200° C. gave a thermionic-current curve which allowing for difference of scale, was identical with the vapour pressure curve of water between 0° and 90° C.

By hypothesis an electron can only escape by means of an atom of free ether replacing it in the solid, and this is the reversible mechanism of radiation or absorption. Incidentally this shows that in the photo-electric effect the effective energy is the pressure of the ether at the sink, as it should be, and not at the source of light. The present theory is similar in principle to the solid space lattice of Dr. F. A. Lindemann (*Phil. Mag.*, Jan., 1915), which makes the specific heat of the electrons negligible. Admittedly, the existing electronic theory of metallic conductivity cannot meet the attacks which have been made upon it. The Lorentz atom with rotating electrons probably only survives because of its mathematical beauty in relation to the Zeeman effect. Radio-activists strongly favour this catherine-wheel firework type of atom, but Prof. Joly states:—"The halo has established the extreme rarity of radio-activity as an atomic phenomenon. One and all of the speculations as to the slow breakdown of the commoner elements may be dismissed."

If a modicum of the mathematical talent, which, since 1897, has been concentrated on the electronic theory of matter were expended upon the material theory of electricity, every known force would be directly traced to the pressure of the ether, insted of being mostly concentrated inside the atom through the naive assumption of action at a distance. The ether pressure deduced from the velocity of light is $79{\cdot}6\times10^{12}$ tons per sq. inch, or $0{\cdot}5\times10^{24}$ dynes per sq. cm. The spherical diameter corresponding to the repulsion of two electrons distant 1 cm. should be $2{\cdot}33\times10^{-11}$ cm. thus:—

$$(2{\cdot}33\times10^{-11})^4\times0{\cdot}7854\times0{\cdot}5077\times10^{-24}=$$
$$=1{\cdot}17\times10^{-11}\text{ dynes.}$$

Although the collective motion of electrons constitutes an electric or thermal current, the truth emerges that the number of electrons per cc. in a metal is not a measure of conductivity but of the resistance in the Wiedemann-Franz inverse ratio. (From *Chemical News.*)

Improvement in the Illumination of Railway Signal Lamps.

During the war, owing to the blockade, there was a dearth of petroleum in Germany, and the defective cleaning of the oil obtained from Galicia caused great trouble with the railway signal lamps, which were designed for the use of the properly cleaned petroleum coming from Russia and the United States before the war. The impure petroleum gave a dim light, and produced a deposit of carbon upon the lamps themselves. The matter became serious, and might have been the cause of railway accidents. The author, Mr. Olbrich, discovered, after numerous experiments, a very simple expedient for overcoming the difficulty. He states that if the wicks be allowed to soak for five hours in a 20 per cent. solution of potassium nitrate, and then dried, the illumination given by the lamps will be wonderfully increased. He advises that the wicks in bulk should be so treated before being distributed to the various stations, as the cost will then be less than if each station has to deal with its own wicks. (*Zeitung des Vereins Deutscher Eisenbahnverwaltungen*, (abstracted by *The Technical Review*).

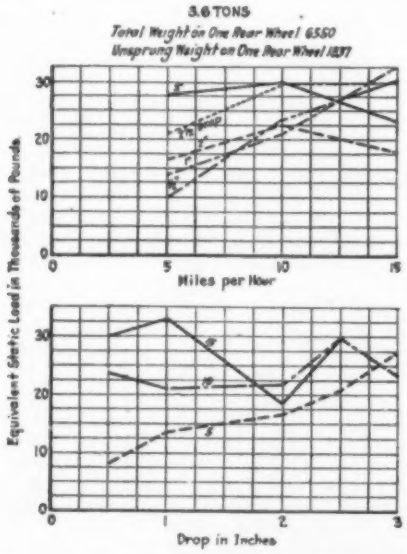
Impact Tests of Motor Trucks on Roads*

Experiments to Determine Road Design and Allowable Speeds and Loads

REALIZING the effect of heavily loaded motor trucks on highways and streets, and feeling the demand for data on the design of road surfaces and foundations to withstand such heavy traffic, a series of experiments is being conducted by the Bureau of Public Roads (U. S. Department of Agriculture) at the Arlington Experimental Farm near Washington to determine the impact of motor trucks on roads.

The apparatus used in these experiments consists of a heavy steel cylinder in which is fitted a plunger 4-in. in diameter and 8-in. long, similar in construction to a hydraulic jack. A hole is left in the bottom of the cylinder to prevent air cushioning under the plunger. On the top or head of the plunger is securely fastened a heavy steel plate on which is received the impact of the truck wheel. This whole apparatus is rigidly supported in a concrete box placed in the road in such a position that the height of the steel plate on top of the plunger can be made just flush with the road surface. The height of the upper surface of the plate can be varied by proper steel disks placed under the plunger. To allow the front wheel to pass over and not touch the steel plate on the plunger, a steel bridge is used which is automatically tripped by the front wheel passing over it. This releases a catch and allows a weighted lever to pull the bridge clear from the apparatus, thus leaving the steel plate exposed and ready to receive the impact of the rear wheel. By slight variations this bridge can be used to allow the impact of the front wheel to be received and then protect the plate from the impact of the rear wheel. The approach to this impact apparatus is made of 2-in. planking about 20 ft. long and is constructed so that the height of the planks can be varied above the road surface to give different heights of drop and also be moved forward or backward to give the proper distance from the jump-off point so that the wheel will strike the center of the plunger at all speeds.

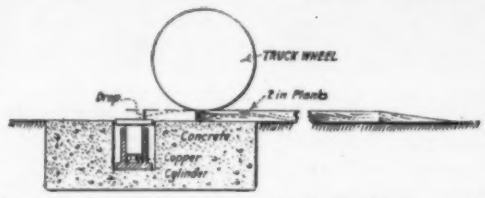
For recording the impact value, a copper cylinder of ½-in. diameter and ½-in. long is placed under the plunger of the jack. The impact received on the plunger is transmitted to the copper cylinder where it produces a corresponding permanent deformation. The cylinders for this investigation were prepared from pure copper bars


3.6 TONS
Total Weight on One Rear Wheel 6550
Unsprung Weight on One Rear Wheel 1837
Equivalent Static Load in Thousands of Pounds
Miles per Hour
Drop in Inches

Results of impact test of a 3-ton truck when carrying a load of 7200 lb.

and carefully machined to dimensions. They were then annealed by heating for 30 min. at a uniform temperature of 650 deg. cent in a bath consisting of a mixture of 20 per cent of potassium nitrate and 80 per cent sodium nitrate, followed by slow cooling in the air at room temperature. This treatment anneals the copper very uniformly. The finished cylinders were tested for uniformity in a universal testing machine under a pressure of 6000 lb. total static load, five cylinders being taken from each heat-treated lot. Thus far the maximum variation from the mean deformation value has been only 1.3 per cent and this is less than other experimental errors.

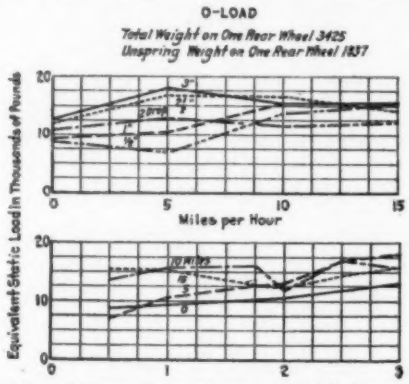
A 3-ton Class B truck, with solid rubber tires, was used for the experiments. The weight of the truck empty is 11,400 lb.; the weight on front wheels, 4550 lb.; the weight on rear wheels, 6850 lb., and the weight of unsprung rear parts, 3675 lb. The deflection of the rear spring under the weight of the body alone is 0.74 in. The weight on the rear wheels when loaded with 7,200 lb. of gravel is 13,100 lb., and the deflection of the rear spring, due to the load and the body is 2.62 in. The weight on the rear wheels when loaded with 10,000 lb. of gravel is 15,500 lb. and the deflection of the rear spring, due to the load and the body, is 3.62 in. The diameter of the rear



Arrangement of apparatus used in the impact tests

wheels is 40 in. and each is fitted with two solid rubber tires, each of which is 6 in. wide at the base next to the rim. Impact values were obtained only for the rear wheel, as it was the object of the test to obtain values of the maximum impact of the truck. The rear springs were 57½ in. long, 4 in. wide and 6½ in. deep, with 17 leaves.

The impact condition under which these tests were conducted was the simple falling of the truck wheel from one level to another at different speeds of the truck, the height of drop varying from ¼ to 3 in. Other conditions


0-LOAD
Total Weight on One Rear Wheel 3425
Unsprung Weight on One Rear Wheel 1837
Equivalent Static Load in Thousands of Pounds
Miles per Hour

Results of impact tests of an unloaded 3-ton truck

of impact will be investigated later. The magnitude of the impact is dependent upon the height of the drop, the weight of the truck and the load, the kind and condition of the tires, the characteristics of the springs and the speed of the truck. Under these conditions, a series of tests was run, and the results are shown on the accompanying curves. The impact, while measured by the shortening or compression of the copper cylinders, is shown in equivalent static load. That is, for each compression value of the copper due, the static load which would produce the same compression has been determined. All the curves are thus shown with the equivalent static load as ordinates. This may not be a perfect comparison of impact loads, as loads applied with impact will probably produce a much localized shattering effect which does not result from the application of an equivalent static load. For this reason, the present methods of comparing impacts by the equivalent static loads must be considered as tentative and subject to possible revision as the tests proceed.

The tests thus far give only the relative impact values, and do not attempt to demonstrate the destructive effect of these impacts. This destructive effect depends upon the road surface, the type of construction and the foundation. To arrive at the destructive effect of these impact forces, it is proposed in another series of experiments to subject certain road surfaces to these same impacts repeatedly until failure occurs. Machinery and apparatus for this purpose are now under construction.

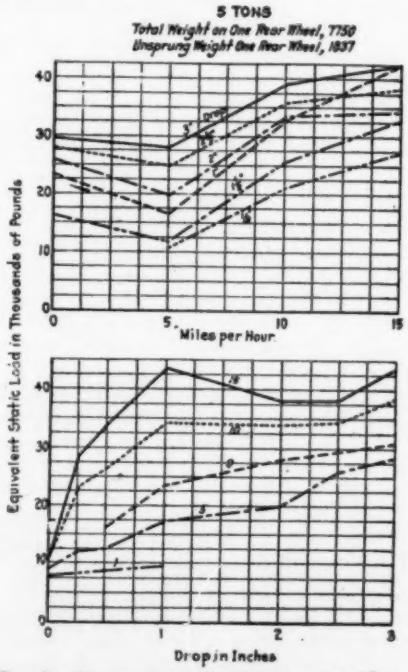
The results shown indicate a general tendency of increased impacts toward the higher speeds, although the increment of increase is less as the speed increases. The relatively high impact values at zero speed are explained by the fact that the results were obtained by dropping the wheel vertically upon the impact plunger. This resulted in the copper cylinder receiving first the impact or kick of the spring and then an additional load an instant later from the falling of the truck body and load.

The same data were plotted with the height or drop as abscissas. These curves indicate a general increase of impact with the increase of the height of drop.

In conducting these experiments it was soon discovered that the action of the truck springs had a great influence on the impact results. When the wheel leaves the jump-off point the spring, it is said, produces a greater downward acceleration of the unsprung parts than that due to the action of gravity alone. If the compression of the spring is e, and the height of the drop or jump-off point is d, then within the time of one vibration of the spring, the magnitude of the impact at the landing point will depend upon whether $d < e$, or $d = e$, or $d > e$. If the period of vibration is such that the spring has acquired its maximum acceleration and at this instant also lands at the point of impact on the road surface, the impact value will be a maximum. The impact value will be a minimum when conditions are such that the spring is returning to its closed position and is at the point of maximum acceleration in this direction as the impact occurs. This explains why the impact values, as shown in the curves, do not consistently increase with the height of drop. The static loads equivalent to the impact values under the higher loads and drops are as much as five times larger than the total dead load.

It was also noticed during these tests that the impact was appreciably affected by the conditions of power on or off. That is, if the impact occurred when coasting, it was less than when the power was being applied to the rear wheels. This difference amounted in some cases to as much as 30 per cent.

These results are presented at this time only for the purpose of showing the general tendency of the impact values. It is the intention to enlarge upon this investigation to determine the relative effects of kinds of tires, loads, speeds, spring characteristics and character of road obstructions and defects which produce impact values and to attempt to arrive at some definite conclusions as to the destructive effect of truck loads on different types of road. It is hoped that this will ultimately result in definite road design data, and also lead to information as to allowable loads and speeds for motor trucks. Special apparatus is being designed to obtain autographic records of the tests.


5 TONS
Total Weight on One Rear Wheel, 7750
Unsprung Weight One Rear Wheel, 1837
Equivalent Static Load in Thousands of Pounds
Miles per Hour
Drop in Inches

Result of impact test of a 3-ton truck with a 5-ton load

Circuits for Undamped Oscillations.

A series-wound dynamo connected to a condenser can, under certain conditions, generate undamped electric oscillations, the frequency of which depends on the values of the capacity and inductance of the circuit. Pestarini, in *Elettrotecnica*, generalizes this device, and shows that in some cases the same result can be obtained without condenser by conveniently interlinking the dynamo circuit with some auxiliary circuits or by interlinking the circuits of two dynamos. To avoid the use of dynamos and of their troublesome commutators, the author sets forth the adoption of a kind of ironless alternator which should, according to the author, allow large trains of undamped oscillations to be obtained. (From *Science Abstracts.*)

* From Automotive Industries. A preliminary report by E. B. Smith and J. T. Pauls. The authors are connected with the Bureau of Public Roads of the Department of Agriculture as senior testing engineer and highway engineer respectively.

Airplane Dopes and Doping*

Shrinking and Waterproofing the Fabric of Airplane Wings

By W. H. Smith

1. HISTORICAL

CELLULOSE acetate and cellulose nitrate are the important constituents of airplane dopes in use at the present time, but planes were treated with other materials in the experimental stages of flying. The above compounds belong to the class of colloids and are of value because they produce a shrinking action on the fabric when drying out of solution, rendering it drum tight. Other colloids possessing the same property have been proposed and tried. In the first stages of the development of dope, however, shrinkage was not considered. The fabric was treated merely to render it waterproof.

The first airplanes constructed were covered with cotton fabric stretched as tightly as possible over the wings, fuselage, etc., and flying was possible only in fine weather. The necessity of an airplane which would fly under all weather conditions at once became apparent. Then followed experiments with rubberized fabrics, fabrics treated with glue rendered insoluble by formaldehyde or bichromate, fabrics treated with drying and nondrying oils, shellac, casein, etc. It was found that fabrics treated as above lost their tension in damp weather, and the oil from the motor penetrated the proofing material and weakened the fabric. For the most part the film of material used lacked durability.

Cellulose nitrate lacquers, however, were found to be more satisfactory under varying weather conditions, added less weight to the planes, and were easily applied. On the other hand, they were highly inflammable, and oil from the motor penetrated the film of cellulose nitrate, causing the tension of the fabric to be relaxed. The film does not possess the objectionable brittleness of glue or casein, and, in general, this type of dope had much in its favor.

About the year 1910, the Bayer Co., of Elberfeld, Germany, began to exploit a type of cellulose acetate known as "cellit" for use on airplanes. This material had been used in the preparation of a noninflammable celluloid called "cellon." Experiments were made with thin sheets of cellon, which were fastened to the fabric to protect it, and this suggested the use of cellulose acetate in solution. In 1910, acetate dopes were used and found to produce a satisfactory shrinkage, and to be proof against water, oil, and gasoline. Such dopes were more expensive than nitrate dopes, but the noninflammability of the acetate film caused a slow but general adoption of cellulose acetate solutions. At the present time such dopes are considered the best for use on aircraft.

Dopes are also used on balloon fabric to reduce the permeability of the fabric to gas. The English Government uses "delta" dope for this purpose, a nitrate dope containing sufficient castor oil to make it nonshrinking. The Navy Department has used "delta" dope on certain airships, on which the fabric had become too permeable to gas, and satisfactory results were obtained. The use of acetate dopes on balloons is receiving consideration.

2. COMPOSITION OF DOPES

A dope consists of the cellulose ester dissolved in suitable solvents to which diluents are added, with the addition of plastics and a compound to neutralize the traces of acidity in the solvents, or the acidity which may develop in the film. The solvent contains a compound of high boiling point which allows the cellulose ester to emerge from the solvent mixture in a transparent condition, free from precipitated cellulose ester which appears in the film in streaks or spots. The development of such whitened areas is known as "blushing." It results from the application of dope in a humid atmosphere, or from the rapid evaporation of low-boiling solvents and diluents, or both. In the presence of a high-boiling solvent, the moisture has a chance to evaporate before the film is dry, and the cellulose ester is not precipitated. The amount of the "high boiler," as it is frequently called, depends upon its boiling point. If the latter is high, less of the compound is needed than when it is low. Solvents with boiling points between 125° and 200° C. are generally used. A high-boiling diluent may be present in nitrate-dopes to assist in the prevention of blushing.

Diluents generally consist of mixtures of alcohols and hydrocarbons, and frequently denatured alcohol and benzene are used.

Plastics are occasionally used in nitrate dopes, but are always present in acetate dopes. The nitrate film has sufficient inherent strength and elasticity without further modification, but a small amount of castor oil or camphor is sometimes incorporated in it. Acetyl cellulose, however, is inherently brittle and certain softening bodies or plastics must be added to it in order to impart suppleness and increase its life. A plastic is frequently a solid of low melting point, sometimes a liquid or a mixture of liquids, and generally a solvent of the cellulose ester with which it forms a solid solution. A small amount of the "high boiler" is always left in the dope film, and this also plasticizes it. A suitable base is generally present in the film to neutralize acidity. The base commonly used is urea.

3. CELLULOSE NITRATE DOPES

Cellulose nitrate or guncotton is produced by the nitration of cotton or some form of cellulose approximating the degree of purity of cotton. For dopes a low nitrated cotton is desirable. It must be stable in order that no decomposition with development of acidity may occur. The high boiler in nitrate dopes is generally amyl acetate or butyl acetate. The former is a product of fusel oil and the latter is prepared from butyl alcohol, a by-product in the production of acetone by fermentation. The diluent is generally a mixture of denatured alcohol and benzene, although methyl alcohol, methyl acetone, and xylol are also employed. A low-boiling solvent, such as ethyl acetate, may be also present. The solvent and diluent combination used in nitrate dopes is influenced by the degree and method of nitration, and therefore is subject to considerable variation.

4. CELLULOSE ACETATE DOPES.

The manufacture of cellulose acetate is a technical art, demanding careful supervision and control. Variations of a few degrees of temperature during the process have an adverse effect upon the product. The correct preparation of the material is known only to a few chemists. It is quite difficult to make two batches of the ester alike, and frequently there is trouble in spite of efforts to keep the quality uniform. The material is a white solid, its appearance depending upon the method employed for its precipitation. A good cellulose acetate has an asbestos-like quality when rubbed between the fingers.

At the outbreak of hostilities in this country, dopes were prepared from scrap acetate film. These dopes did not give results in service, which should be expected of cellulose acetate. The film scrap was frequently old stock, and contained plastics. In the preparation of dope it was dissolved in suitable solvents with the addition of dope plastics. On this account the dope film was frequently overloaded with softening agents.

The commonest "high boiler" used in this country in acetate dopes is diacetone alcohol, a product of acetone obtained by condensation in the presence of lime. In Germany, before the war, ethyl lactate was the "high boiler" in common use. This substance has a tendency to break up into ethyl alcohol and lactic acid unless certain compounds are added to it to make it stable. Methylethyl ketone in suitable amount also prevents blushing, but not as effectively as the preceding compounds, unless a considerable amount is present. In this connection it may be pointed out that a suitable proportion of alcohol and benzene, when present in the dope, removes much of the moisture present. A certain mixture of alcohol, benzene, and water has a higher vapor pressure than any of its constituents, and when this mixture results during evaporation water is readily removed. Acetone oils are also used as high boilers, but the composition of these oils varies greatly; and, because they may break up with the development of acidity unless carefully purified, they have not found as much favor as compounds of known purity.

Solvents are usually acetone, methyl acetate, methyl acetone, tetrachlorethane, and ethyl formate. Acetone has not been used during the period of hostilities because it has been needed in the preparation of cordite and for other purposes. The preparation of methyl acetate involves less consumption of acetate of lime than the production of acetone, and hence has been preferred because its use conserves raw material. Methyl acetone is a product of the destructive distillation of wood. It is largely a mixture of acetone and methyl alcohol, and when the latter is acetylated, water removed, and acid present neutralized, a good solvent results. The composition of methyl acetone varies considerably, and sometimes it is necessary to increase its solvent power by the addition of methyl acetate or acetone. Tetrachlorethane was formerly a favorite solvent in acetate dopes. It combines the functions of a solvent and plastic and dissolves cellulose acetates of a wide degree of hydration. However, its vapor has been shown to be about four times as toxic as that of chloroform and unless pure it decomposes and causes deterioration of the fabric. The vapor of the compound causes jaundice, and in England several fatalities resulted in the application of dopes containing it. The decomposition of tetrachlorethane can be prevented by the use of suitable pigments, and the danger attending its application could be nullified if all doping rooms were provided with adequate means of ventilation. Unfortunately, ideal conditions of ventilation do not exist, and one by one, the Allies have all abandoned the use of tetrachlorethane dopes. France and Italy have even ruled out dopes containing chlorine in any form.

Ethyl formate has not been used in the United States but is allowed by the British Government. It is an excellent solvent.

Diluents commonly used are denatured alcohol and benzene, sometimes methyl alcohol, either added as such or present in methyl acetone. Cellulose acetate dissolves in a mixture of alcohol and hydrocarbon when warmed and is reprecipitated in the cold, but the solubility persists in the presence of a solvent of cellulose acetate such as acetone. When the ratio of hydrocarbon to alcohol is three to one, an increased amount of diluent may be used.

The plastics which have been proposed for use in acetate dopes include many compounds, some of which are much superior to others. Benzyl alcohol is used by the British Government. Mixtures of eugenol and triacetin have found favor in France. In this country, the commonest are phenyl salicylate, which is an excellent softener, mixtures of benzyl benzoate and benzyl acetate, benzyl acetate alone, and triacetin. Triacetin is water soluble, and may decompose with the liberation of acetic acid. Triphenylphosphate is in universal use in acetate dopes. It waterproofs and fireproofs the film, and is an excellent softener. When used in excess, however, triphenylphosphate softens in warm weather and makes the acetate film soggy. Urea is used in small amount to neutralize any free acid which may be present.

5. DOPE COVERS.

The dope, as has been previously mentioned, protects the fabric, keeping it taut, so flying is possible under all weather conditions. It is also necessary to protect the dope film by covering it with some suitable coating containing pigments to exclude light rays. Either pigmented dopes or varnish enamels are used for this purpose. It has been conclusively proven by Dr. Ashton, attached to the Royal Aircraft Factory, that the deterioration of dopes is practically entirely caused by sunlight. His results show that the curve of the intensity of sunlight and the curve of deterioration of doped fabrics are almost identical. It is therefore more feasible to use a pigmented dope or a pigmented wood-oil varnish, rather than clear dope or varnish as a dope cover. Clear varnish has until recently been used in this country on Army planes. The Navy has used a gray, pigmented varnish enamel. Dr. Ramsbottom, also attached to the Royal Aircraft Factory, has recently demonstrated that doped fabrics covered with pigmented dope retain their tautness longer than similar fabrics covered with an enamel. He also demonstrated that a pigmented dope retains its tautness best of all, and that such a dope effects a considerable saving of cellulose acetate. The English Government for a long time has used a type of pigmented dope, khaki colored by iron pigments and lampblack, which is called P. C. 10. It is a nitrate dope containing the pigments and sufficient castor oil to reduce to a minimum the shrinkage ordinarily effected by a dope. Reports from the front indicate that the use of such a cover has been attended by excellent retention of the tautness and durability over a long period, and Dr. Ramsbottom's suggestion regarding pigmented dopes therefore merits serious consideration.

6. APPLICATION OF DOPES.

In the application of dopes to fabrics, it should be remembered that the fabric does not of itself shrink in the sense that mercerization causes shrinkage. In other words, there is no physical change occurring in the fabric. The dope film contracts when drying out of solution and diminishes the space between the threads the total effect of which is slightly to reduce the original area of the fabric. The British Government at one time used a dilute solution of dope next to the fabric. This was called a scratch coat. The dope contained very little softening agent and produced maximum shrinkage. The scratch coat, however, was

(Concluded on page 390)

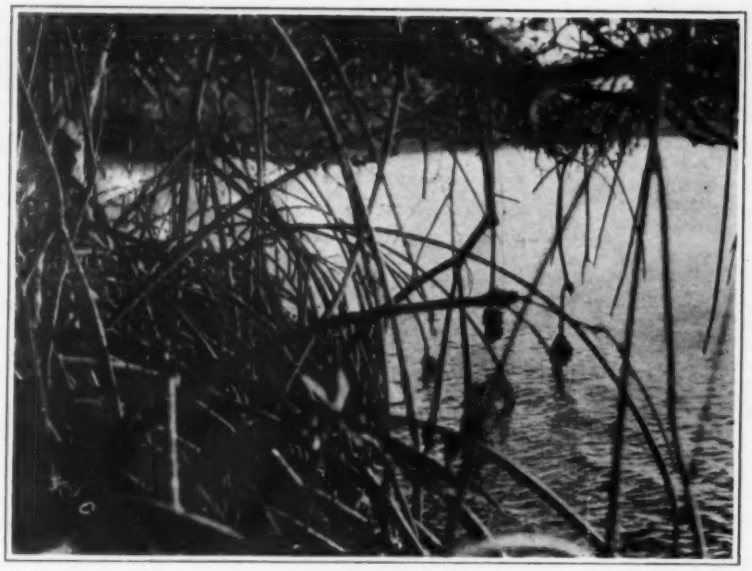
* Report No. 38. From Fourth Annual Report of the National Advisory Committee for Aeronautics.

The Mangroves of Tropical America

A Little Known Factor of Much Value in Our Commercial Geography

By C. D. Mell

MANGROVE is the name commonly applied to certain glossy-leaved trees peculiar to the seaside swamps or their borders. The typical species of this group is the red mangrove (*Rhizophora mangle*) known simply as mangle by the Spanish-speaking people of tropical America where this tree forms impenetrable barriers for hundreds of miles along the mud shores of all low coasts. It grows abundantly in extreme southern Florida where it occurs along the lower courses of all rivers and often penetrates into the seas as far as low water mark. The mangrove is a purely tropical growth and forms the most widely distributed tree in both the new and old world. In the American tropics it forms a dense growth around all the islands of the West Indies and along the main land from Vera Cruz, Mexico, southward to Rio de Janeiro, Brazil. It is found likewise on the west coast of Mexico, Central and South America.



The arching roots from the trunk and lower branches of the mangrove

The tree is remarkable from the fact that it grows in the sea. The stem springs from a number of slender widespreading roots which are unlike those of other trees in that they develop above the ground for five or six feet and curve outward and downward into the mud forming a series of arches. The growth of these roots is so dense that it is practically impossible to pass through parts of these mangrove swamps. It is, therefore, very difficult to operate in these forests to get out the logs or the bark which represents its chief commercial product.

The trees in many parts develop large dimensions. The average tree is from 60 to 80 feet in height at maturity and from one to three feet in diameter. The wood is very strong and hard, bears the water well, and is much used in parts of the West Indies for knees and ribs of boats for which the archings and angles of its limbs naturally adapt it. The forests of this species were at one time exploited in Southern Florida in the vicinity of Cape Sable, but it was too expensive to transport the logs and bark to the boat landing. The logs were cut into boards for use in flooring and interior trim. In Ecuador most of the houses along the coast are built of mangrove wood and practically all wharves are constructed of it for which it is highly esteemed. Its principal uses are for fuel and charcoal.

Red mangrove produces the bulk of the commercial bark used for tanning purposes. It is much prized as a tanning material and large quantities are imported annually for this purpose. The bark, which is from three-fourths to one inch thick, of a dull reddish color, somewhat fibrous and covered with a grayish cork-like cuticle, contains tannin superior to that of many other barks used for that purpose. Its color is of a rather deep red which is cited as an objection to its being brought into still greater use. The Bulletin of the Imperial Institute (London), Vol. No. 4, 1907, page 346, states that mangrove bark contains 25 per cent. of tannin, while some authorities claim that it runs as high as 35 per cent.

The gathering of the bark is an exceedingly difficult undertaking, and the work is attended by many hardships. Work commences at the beginning of the growing season (wet season), when the bark can be removed readily from the trunks of the trees felled. The dense growth in the mangrove forest makes felling difficult, but after the tree is down the bark is removed from the trunk and is carried by men to the small boats (dugouts) and transported to a central station where the whitish outer layer is removed by means of a machete. This facilitates drying considerably and in so doing fully 50 per cent. of the weight is lost. The pieces are usually about four feet long and from six inches to a foot wide in which form it is stacked up like cordwood. When it is dry and ready for the market the bark is broken up into small pieces so as to facilitate packing it in bags for export. Great care is taken not to allow the broken or cut pieces to become wet or to absorb too much moisture after it has been put in bags and is ready for shipment. The prices at source of origin vary considerably depending upon the quality. The present prices are ruling high, but during normal times one cent per pound is considered a good price in the tropics. In some parts of Brazil good quality bark has been sold recently as high as 5 cents per pound f.o.b. shipping port.

During 1917 the total quantity of mangrove bark imported from all parts of the tropics amounted to 10,565 tons, valued at $297,897. Of this amount 2,524 tons came from the American tropics, chiefly Venezuela, while the remainder, 8,041 tons, originated chiefly in Portuguese West Africa. The supply of mangrove bark in tropical America is unlimited and there is no reason why the industry should not be greatly developed. Instead of drawing four-fifths of our requirements from far off southern Africa the American importers and users should look to the south of us for their raw material where it is closer at hand. Moreover, we owe it to our tropical American neighbors to help develop their natural resources.

The Commotion Factor in the Ætiology of Shell Shock

(*Continued from page 378*)

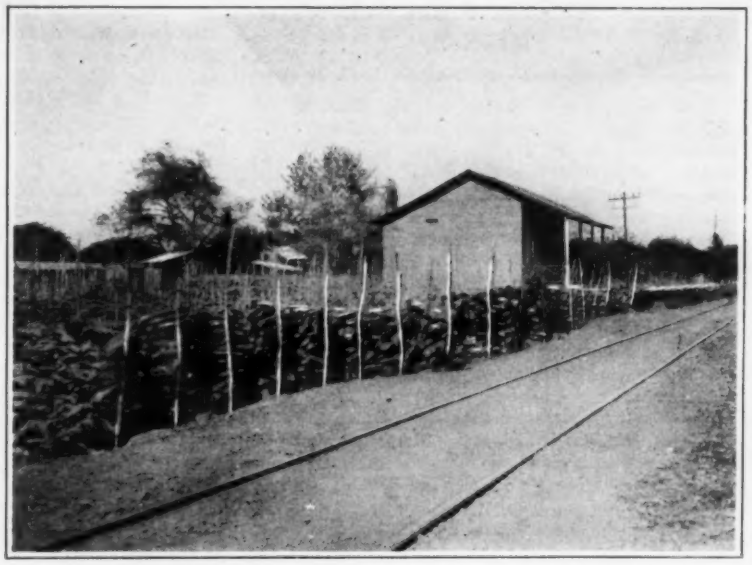
was sheltered in a well-protected dug-out about 100 yards from X, the centre of detonation. In this case X was a large crater formed in the centre of the demolition ground, and contained the official maximum weight for each single destruction—viz., 200 lb.

Although the men had some technical knowledge they did not know the nature of the explosive fillings which were to be destroyed on any given occasion, and it was interesting to study the differing effects of these upon them. Simple single fillings, such as T.N.T., picric acid,

Removing with a machete the corky outer portion of the bark

Cutting up the logs for fuel after recovery of the bark

Red mangrove bark ready for the market



The red mangrove fire wood of the tropical American coast

and tetryl, rarely caused any of the men discomfort under the conditions described, yet when mixtures such as ammonal (British), amatol (British and German), donarit and glückauf (German) were detonated many of the men complained of unpleasant sensations—e.g., "catching in the throat," "peculiar feelings in the chest," "creepy feelings down the spine," or "weakness of the legs"; others were seen to shake violently and the rate of their pulse and respiration increased.

When separated or layered fillings of different explosives having widely differing velocities of detonation were demolished the effects became greater and several of the men passed into a stuporose condition, followed in some instances by violent shaking and twitching, and in one case by vomiting.

Men thus affected were not fit for duty for the next two or three days, and even then, although fully aware that no real danger attended the demolitions, they seemed to be in a state of mental anxiety and were more readily affected by detonations than perviously.

EFFECTS OF DETONATIONS OF SHELLS WITH LAYERED FILLINGS.

Examination of German shells shows that in certain of them layered fillings were deliberately employed, although involving more time and labor. Captured German documents reveal the fact that this type of shell was intended for use immediately prior to an attack, and in sectors where the opposing troops were well entrenched. Hence we must infer that the Germans were aware of the peculiar demoralising effects which attend the detonation of these mixed and layered fillings.

Most of those who have been through a severe German bombardment bear witness to the demoralising effect it had upon them, and state how this was succeeded, owing to summation of effect as the bombardment continued, by a sort of "fixed glassy feeling" even when the shell did not detonate particularly close to them. In order to eliminate as far as possible, if not entirely, the psychic factor which in such cases plays its part it is instructive to study cases in which the detonation fell like a "bolt from the blue" upon individuals who were not in a state of tense expectation or fatigue at the moment of the incident.

At the same time one cannot ignore the importance of the predisposing factors, which are highly complex. There is, however, nothing distinctive about them as regards the type of neurosis developed. So far as my observations go the most important of them—viz., fatigue both physical and mental—seem to operate in a general way by lowering the resistance of the individual to all forms of shock, though naturally the individual of poor make-up is more profoundly affected than the robust type.

COMMOTION FROM "DIRECT CONCUSSION."

First to deal with the syndrome in cases where commotion resulting from "direct concussion" without wounding, as in animals exposed in the B zone, is the primary causal factor.

The initial symptom is unconsciousness, often of several hours' duration and possibly persisting for days. Consciousness when first recovered does not remain clear, but the patient passes through a stage of variable duration during which he loses and regains it—the so-called "dipping of consciousness." Some degree of aphasia and sphincter troubles are common at this stage, which is frequently associated with an active delirium in which the patient re-enacts episodes of his military service.

At this time the general condition is one of extreme exhaustion; all mental operations are sluggish and there is great difficulty of concentration. Amnesia both for immediate and remote past is a common occurrence. The voice is often altered, becoming slow, monotonous, and higher pitched than normally. In severe cases these symptoms tend to persist for many months, and relapses are easily induced by any form of fatigue.

Clinically the importance of recognising these symptoms is that the prognosis in such cases is much graver than in those giving an exaggerated account of events after they had been thrown down or partially buried. In cases exhibiting the above symptoms prolonged rest, with freedom from strain of all sorts, is essential. Psychotherapeutic treatment is of little avail except in so far as fixation of symptoms may have occurred in the later stages.

"INDIRECT CONCUSSION."

Cases of "indirect concussion" corresponding to animals on the borders of the B and C zones demand more careful discrimination. The history is complicated by the fact that there is a tendency on the part of the patient to exaggerate, but careful questioning will overcome this difficulty.

Unconsciousness or stupor of comparatively brief duration is the rule, and the phenomenon of "dipping of consciousness" is not observed. Active delirium is rare, and is not of the occupational type. Amnesia though frequently present is only retrograde, is less extensive, and more readily recovered than in the type of case previously described.

The severity of the symptoms, as well as their duration, is also less, but there is a greater tendency to the superimposition of functional troubles such as paralyses and algesias; these may supervene immediately but, more commonly, they develop later in the course of the disease when the symptoms of commotional origin are recovering. If they are removed by appropriate treatment the patient, after a few weeks' complete rest, generally feels as well as ever. Easy fatigability and diminished power to concentrate the attention are apt to be more persistent symptoms, and although the patient declares himself "quite fit," it is advisable to insist upon a more prolonged period of rest.

"THE LAST STRAW"

Cases in which the neurosis arose as the result of exposure to shell fire in what I have referred to as the C zone are naturally much more difficult to differentiate from those of purely psychogenic origin, and it cannot be said that they are recognisable by a distinctive syndrome. The description already given of men so exposed in the "Ammunition Proof and Demolition Ground" affords a better picture of the onset of the neurosis than can be got from an analysis of the more complicated conditions arising during trench warfare.

In a rather disparaging way any shell detonating outside the A zone is commonly referred to as merely "the last straw," its influence being thus tacitly attributed to purely emotional factors. It is, nevertheless, a last straw which cannot be lightly disregarded, and one is justified in maintaining that a sufficient number of such "straws" will cause the downfall even of the most robust.

It should be remembered that the stability of any explosive is under these conditions diminished, and its sensitiveness so raised that it may eventually detonate. There is no difficulty, then, in conceiving that physical processes, which cause alterations in the direction of *instability* in a relatively simple chemical compound such as an explosive, may, in a similar way, affect the far more delicate colloidal solutions contained in the central nervous system.

COMBINATION OF PHYSICAL AND EMOTIONAL CAUSES.

With cases of purely psychogenic origin, many of whom never reach the danger zone, it is not my purpose to deal. The syndrome closely resembles that with which we are familiar in civil life, though the "current conflict" is usually of a different nature. Psychological analysis reveals the repression and the conflict which is being shirked.

The point which seems to have been universally overlooked is that under the conditions of modern warfare the soldier is constantly subjected both to physical and emotional causes of shock, and that the two factors operate in conjunction. Also whichever factor be in any given case the primary one the individual, once sensitized by either, remains for a long time, perhaps always, hypersensitive to both forms of stimulation, and a vicious circle is thus established.

Although one not infrequently meets with cases in which apparently a single factor has been operative, a careful study of histories in the special military neurological hospitals has led me to conclude that the combined action of the two ætiological factors is much the more common event. If this be so, it is not surprising that those who expect to find either definite commotional or emotional syndromes in the bulk of their patients are generally disappointed.

CONCLUSION.

I have tried with the aid of the experiments, here briefly set forth, to give a picture of the early syndrome which distinguishes the more severe cases of commotional shock, but as the experiments themselves no less than clinical experience indicates, the symptoms in slighter cases become almost inextricably blended with others which appear identical with those resulting from emotional shock. Hence, though at the two extremes one may with ease deduce the nature of the primary pathogenic factor from a study of the syndrome exhibited, this becomes increasingly difficult as one approaches the intermediate members of the series, and one's judgment is largely determined by the aspect from which one approaches the problem.

The Use of Water for Rock Blasting.

A WRITER in *Zeitschrift für Schiesswesen* describes a hydraulic device for blowing up rocks, and, in particular, for demolishing bridge piles and ferro-concrete foundations. It is based on the principle of the hydraulic press; enormous pressures are set up within the rock, which eventually bursts. The pressure is transmitted by a pipe-line to a cylinder 85 mm. diam. in which eight pistons may be successively displaced telescopically. The cylinder is inserted into a hole, drilled by an electric drill in the rock to be blown up. The pistons bury themselves in the rock one after another and blow up the rock. The holes take 10 to 15 minutes to drill (they are about 2.5 cm. deep), and in 5 minutes after that the rock is shattered. It is said that this device has proved successful in mines and quarries where the use of explosives would be dangerous. From *The Technical Review*.

Notes on Troubles From Colloids in Flotation*

Review of the Opinions of Flotation Experimenter

SOME notable papers dealing with the effects of colloids on flotation have recently been published. The phenomenon is well known to every operator of the flotation process. It consists in the fact that otherwise good flotation ores cease to be amenable to treatment by the process when they contain more than a certain amount of matter of a colloidal character.

The term "colloidal" may require defining. A. Schwarz [1] calls attention to the formation of colloids from the flotation oils, tars, and like substances, and objects to the term "colloid" applied to ore slime. Though the dispersion of such slime may not be fine enough to fall strictly into the "colloid" class, the word is used here in a broader sense, as it has been employed by many others without implying any assumption about the fineness and the degree of dispersion.

The action of the colloidal material, which exists in all ores to a varying extent and which is produced by the natural decomposition of the ore deposits, has so far received the greatest attention. The phenomenon has occasionally been described as an influence of the primary slime on flotation.[2] Although slime formed by the crushing of the ore in the milling process (secondary slime) generally shows the characteristic action of the primary slime to a much smaller extent, it has recently been definitely established, through work on molybdenum ore carried out by Will H. Coghill for the U. S. Bureau of Mines, that it may also be decidedly harmful.

How much the flotation qualities of an ore vary with the presence or absence of primary slime is shown in a table given by Rudolf Gahl, representing the flotation qualities of the different screen-sizes of an ore:

SCREEN-ANALYSIS OF ORE DRAWN FROM MILL BINS AND FLOTATION TESTS OF DIFFERENT SCREEN-SIZES

Screen Size	Per Cent by Weight	Cumulative Per Cent	Per Cent Total Copper	Copper Contents	Per Cent Oxidized Copper	Contents Oxide Copper	Flotation Results Per Cent Total Copper: Tails	+ Midds. + Conc.	Recovery Per Cent
+ 1 inch	30.8	30.8	1.05	0.324	0.13	0.40	0.22	12.8	80.5
+ ½ inch	17.1	47.9	1.34	0.229	0.11	0.19	0.22	17.4	84.7
+ 4 mesh	23.0	70.9	1.44	0.332	0.12	0.28	0.17	17.1	89.0
+ 8 mesh	4.3	73.2	1.42	0.061	0.12	0.05	0.17	16.3	88.8
+ 14 mesh	5.1	80.3	1.77	0.068	0.13	0.07	0.26	16.8	86.7
+ 28 mesh	4.1	84.4	2.14	0.080	0.14	0.06	0.61	16.3	74.3
+ 18 mesh	3.1	87.5	2.62	0.081	0.19	0.06	0.72	11.3	77.5
+100 mesh	2.4	89.9	3.29	0.079	0.24	0.06	0.63	22.5	83.1
+200 mesh	2.0	91.9	3.16	0.063	0.27	0.05	0.60	20.1	83.5
−200 mesh	8.1	100.0	1.53	0.124	0.43	0.35	1.57	1.48	....
Average	....	.....	1.44	1.441	0.16	0.157	....	....	....

The various screen products were reduced to a fineness permitting their treatment by flotation and then tested in laboratory flotation machines. The inference may be drawn from the table that none of the sizes from which the primary slime had been removed offered difficulties in flotation, though the screen-size in which it collected did not yield to flotation at all.

In a paper issued by the Bureau of Mines,[3] Frederick G. Moses explains the phenomenon by pointing out that the relations between gangue and economic mineral on the one side, and water and oil on the other side, are materially changed by the introduction of colloids, and that, therefore, the flotation qualities of the pulp which depend on these forces are changed also. Similar effects on the molecular surface forces are traceable to physical sources like heat, or to osmotic and electrical influences resulting from the addition of electrolytes. The benefit derived from heat and the addition of salts may therefore, it is reasoned, be ascribed to their action on the surface forces. This explanation, if used as a working hypothesis in experimental work, may well be the means of securing a clearer insight into the basic principles of the flotation process.

GRANULAR SAND AS A REMEDY FOR SLIME TROUBLES

The deleterious influence of primary slime on flotation is too well established to be doubted; it is a fact that many flotation operators know only too well. A question exists, perhaps, regarding the relative damage which it does. Moses mentions that when such slime is diluted by sand its effect is masked. This may be construed to mean that the slime is just as bad after the mixing as before, but it does not appear that Mr. Moses intends to state this, because in another place in his paper he mentions the possibility of mixing the refractory slime with granular ore as a remedy. "Masking" the effect of a harmful ingredient by mixing it with normal ore would certainly be the last thing the metallurgist should do, unless the mixing had other advantages.

PEARCE'S WORK ON THE RETARDATION OF SAND

Questions along similar lines are discussed in another article written by Jackson A. Pearce.[4] Mr. Pearce, like others, has tried to utilize the known facts regarding colloids, and describes a flotation machine which he built with the object of retarding the passage of sand through it, thereby increasing the proportion of sand which exists in the machine. This proportion, it is needless to say, may be quite different from the proportion that exists in the ore fed to the machine or leaving it. He seems to feel reasonably sure that the success of his machine, which made it possible to treat ores that were refractory in other machines, is due to the application of this principle.

QUESTION OF FLOW SHEET

The combined treatment of sand and slime in a flotation machine, although it seems to be the correct method for the treatment of some ores, cannot claim to serve for all ores, for though it apparently presents advantages for the recovery of refractory fines, it offers the drawback that it introduces coarse grains, which are naturally difficult to lift, into a medium which itself may be quite refractory. In cases where emphasis has to be placed on the best recovery of the coarse mineral grains, it seems to be the best course to treat such granular material separately and to avoid all contamination with colloidal matter. This procedure, previously recommended by Rudolf Gahl for certain cases, is also advocated by Mr. Pearce, and apparently practiced by him.

As far as the selection of the proper flow sheet for a certain ore is concerned, it seems to be preferable to treat the combined sand and slime, if no serious difficulties are encountered in the recovery of the coarse mineral, and to provide separate treatment if the flotation of the coarse grains is difficult, provided that the slime by itself is not refractory. In other cases a combination treatment would seem to be the logical solution.

ARE THE PHYSICAL OR THE CHEMICAL QUALITIES OF PRIMARY SLIME RESPONSIBLE FOR ITS ACTION IN FLOTATION?

Although there does not seem to be any doubt that the colloidal primary slime is decidedly harmful in flotation operations, it is not absolutely established that the colloidal properties are what causes the trouble. For it is a fact that that portion of the ore also differs in other qualities from normal ores. The ore freed from slime, for instance, when brought into contact with the mill solution, may give up hardly any soluble constituents to the water, but the primary slime, when treated with water by itself, often sets free noticeable quantities of such salts. Although no analysis of such solutions is available, it seems reasonable to suppose that in the case of copper ores they contain iron and copper salts and probably organic matter also.

To decide what characteristic of the slime causes the harmful effect would seem to be an easy matter. Segregating one part from another should give the answer. This has been tried by thoroughly and repeatedly washing the slime with water. The flotation treatment of the washed slime gave better results than that of the natural slime, but it was still far from being satisfactory. One might, therefore, feel tempted to conclude that the action of the primary slime was due to a combination of its physical and chemical qualities, if certain that all the chemical ingredients that might cause the action had been removed by washing. However, this conclusion may not be safely drawn, as it might well be that the absorption of the salts to the colloidal slime particles is of such a magnitude as to prevent thorough elimination of the harmful ingredients by simple washing. A possibility seems to remain, therefore, that the colloidal fraction on the ore is not harmful by itself, but that all the harm is done by the chemical products of the natural decomposition.

The fact that small additions of chemicals sometimes are decidedly helpful would perhaps better agree with a chemical theory than a physical one, although the addition of small amounts of chemicals also influences the physical characteristics of ores, for instance, by causing coagulation, which is said to be of prime importance. A comparison of the settling qualities of slime to which various chemicals are added, with the flotation qualities of such mixtures, would help to clear this question. So far, apparently, no such relation has been established.

A reference should be cited here that might be investigated, because it could have a bearing on these questions. It is contained in a British patent granted to A. A. Lockwood [5] and points out the advantage of agitating slime with granular, preferably siliceous, sand previous to subjecting it to the gravity-concentration process. The inventor claims that, by doing this, gangue materials that have a tendency to float, like mica, are by the preliminary treatment kept from doing it. The similarity with the case under consideration, where the admixture of sand is regarded as beneficial, because it prevents an excessive amount of gangue material from floating, is apparent, and points perhaps to a relation between the two phenomena.

* From *Engineering and Mining Journal*.

[1] *Chem. & Met. Eng.*, Vol. 19, 1918; p. 701.

[2] Rudolf Gahl, "History of Flotation at Inspiration," *Trans.*, A. I. M. E., Vol. 55, 1917; p. 576.

[3] Technical Paper No. 200, U. S. Bureau of Mines, "Colloids and Flotation."

[4] *Min. & Sci. Press*, Vol. 117, No. 15; Oct. 12, 1918; p. 491.

[5] British Patent No. 174; 1915.

Airplane Dopes and Doping

(*Continued from page 387*)

found to reduce the tear resistance of the fabric and was, therefore, abandoned. Such a coating penetrates the fabric very thoroughly and locks the fibers and threads. It is apparent that the viscosity of the dope must permit of some penetration, so that the dope will not peel off, but the penetration must not be excessive. The amount of size in the fabric to some extent influences penetration. The first coat of dope is well worked into the fabric and subsequent coats are flowed over it, care being taken not to go over a given area more than once or twice, or the doping brush will drag on the dope film. Sufficient dope is applied to produce a weight increase of 2 to 2.5 ounces per square yard. The Army specifications require four coats of dope on all planes, and specify nitrate dope on training planes and acetate dope on combat planes. Two coats of clear varnish or enamel are applied over the dope.

The Navy Department specifies two coats of acetate dope over the fabric, followed by three coats of nitrate dope and two coats of navy-gray enamel. The inflammable nitrate dope is thus laminated between the relatively fire-resistant acetate dope and the enamel, the pigment in which also affords resistance to fire. It has been contended that the use of one type of dope above the other may produce two films of different physical properties, but to date no trouble has been experienced by the Navy in the durability of dopes applied as above.

7. FIREPROOFED DOPES.

Inasmuch as nitrate dope is comparatively cheap and acetate dope expensive, numerous attempts have been made to reduce the inflammability of the nitrate film. This has been attempted by fireproofing the fabric or dope or both. Fireproofing is generally effected in one of three ways—by encasing the material in a coating of inert mineral salts, by using compounds which decompose with the liberation of a gas which checks combustion, or by incorporating an organic fireproofing compound in the dope film.

Any compound used for checking the spread of combustion should not dissociate with an acid or alkaline reaction in the presence of moisture, as acids, particularly mineral acids, attack the fabric, and alkalies have a saponifying action on cellulose esters and certain plastics. A great variety of fireproofing solutions for fabrics and fire-resistant dopes have been submitted to the Bureau of Standards for examination. The best treatment for fabrics has been found to be a 10 per cent. solution of ammonium phosphate neutralized with ammonia. This has been found to exert no deleterious action on fabric or dope. Soluble chlorides in general have been found to weaken the fabric.

Several pigmented fireproofed dopes have been examined. The pigments used have consisted of finely ground ammonium phosphate or magnesium ammonium phosphate. These are incorporated in suitable proportion in a fine state of division in a nitrate dope. The dope is applied alternately with clear dope, one coat of pigmented dope on the fabric, then clear dope, then pigmented, etc., five coats in all. A pigmented varnish is applied over the dope.

Several fireproofed dopes resembling an English product called "titanine dope" have also been submitted. These consist of nitrate dopes containing chlorides of zinc, calcium, or magnesium added in alcoholic solution. The hygroscopicity of these salts is objectionable, and such dopes tend to become slack on the fabric in humid weather. This can be overcome in part by laminating the dopes between coats of clear dope.

Nitrate dopes may also be fireproofed by incorporating tricresylphosphate or hexachlorethane in the dope film. The former compound is preferable and forms a better solid solution with cellulose nitrate than triphenylphosphate. It is necessary to fireproof the fabric when dopes of this type are applied.

Rate of Deionization of Electric Arc Vapor

A DIRECT current arc in a vacuum is maintained by the ionising effect of the current. When the arc is stopped for an instant the gas between the arc electrodes becomes deionised. H. G. Cordes, in *Institute of Radio Engineers, Proceedings*, suggests a method for measuring the rate of this deionisation, and also the effect on this rate on the voltage required for a subsequent reignition of the arc.

If certain quantities can be measured sufficiently accurately the method outlined should give important results of practical application.—From *The Technical Review*.

X-Rays in Medical Science

By A. C. Jordan, M.D., M.R.C.P.

THE discovery of X-rays in 1895 was justly hailed as one of the greatest scientific marvels of any age. Medical men eagerly grasped the possibilities of these rays, which enabled them to see the internal organs of their patients actually at work, hitherto impossible even to surgeons, who in the course of their operations had the organs exposed to view, but only under conditions of anæsthesia.

The first practical uses to which X-rays were applied were: (1) In the detection and localisation of metallic foreign bodies, such as needles and bullets; (2) in the detection and localisation of metallic or other foreign bodies that had been swallowed; (3) in the diagnosis of fractures of bones: this branch of radiology has made enormous strides during the war, and has led to a vast improvement in the treatment of fractures and to the saving of countless limbs; (4) in the diagnosis of calculi in the urinary tract and elsewhere: these foreign bodies throw shadows which have to be distinguished from concretions in the bowel and calcareous deposits; many pitfalls lie in wait for the unwary observer, and the right interpretation of these shadows, even at the present time, calls for skill, patience, and discrimination; (5) in the diagnosis of diseases of the chest: the appearance of the normal movements of respiration and of the beating heart was closely observed, and as a result of these observations upon healthy subjects this branch of physiology has had, to a large extent, to be rewritten. The position of the heart and vessels in the chest—in the midst of the air-filled lungs—rendered accurate diagnosis difficult by the older methods of physical examination, but by means of X-ray examinations with the fluorescent screen the mechanism of the heart has been closely studied and its diseases accurately diagnosed.

In regard to diseases of the lungs, pneumonia, pleurisy, abscess of the lung, tumours, enlarged glands in the chest, and many other conditions produce characteristic shadows on the fluorescent screen, and enable the site, nature, and extent of the disease to be determined. In pulmonary tuberculosis the aid which X-rays have brought to its early diagnosis, and in defining its extent, has proved of such value that this means of diagnosing phthisis is playing an essential part in the campaign in progress for dealing with this scourge. X-ray study has shown that the first changes which occur in the lung in this disease lie so deeply buried in the chest—under cover of a thick layer of healthy lung—that they are quite beyond the reach of the older methods of detection by percussion and auscultation. By the time the stethoscope is able to discover the signs of consumption, the disease is probably so far advanced that the prospects of a cure are remote. The diagnostic utility of X-rays has increased steadily with the continued improvement in the apparatus and the increased skill and experience of those engaged in this branch of science.

The correct estimation of fractures and other injuries to bone and joints necessitated an accurate study of the form and texture of normal bones, as well as the individual variations that occur in the conformation of bones and their joint surfaces. This knowledge led at once to a most important extension of the diagnostic powers of X-rays—the recognition of disease in bone and the differential diagnosis of many diseases of bones and joints.

So far we have considered radio-diagnosis as dependent on differences of density among the tissues. Bone, with its lime salts, is far more opaque to X-rays than muscle: consolidated lung is more opaque than healthy, air-filled lung. At first sight this precludes from the range of radio-diagnosis a very important part of the body—the hollow viscera constituting the digestive tract. Very little information is to be gained from an ordinary X-ray inspection of the stomach and bowels, but the introduction of opaque substances into hollow organs with the object of determining their outlines and of observing abnormalities of size, shape, or function has opened up an entirely new extension of the science of radio-diagnosis.

An "opaque meal" consisting of a heavy insoluble salt, such as carbonate of bismuth, is given in a dose of 2-4 oz. Its progress is observed through the œsophagus into the stomach and duodenum, and observations are continued at intervals to note the position and behaviour of each part of the small and large intestine as the bismuth passes through. By this means much new information is being gained concerning the physiology and the diseases of the alimentary tract. Our views regarding the causation and nature of many of the affections of the digestive system have had to be reconsidered and modified.

Medical and surgical text-books of a few years ago contained separate chapters devoted to individual diseases, such as gastric ulcer, duodenal ulcer, gall-stones, and appendicitis, but when radiologists were called upon to aid in the diagnosis of these various diseases they tendered evidence that showed conclusively that these diseases were not isolated morbid affections of the organs concerned, but "end-results" of a more general derangement of the digestive system. In other words, the stomach or appendix does not "go wrong" by reason of any intrinsic vice, but because it is in an environment which has become vitiated or unhealthy.

An entirely different aspect of our subject is the application of X-rays to the treatment of disease. From observations upon the far-reaching consequences of undue exposure to the action of X-rays, radiologists were led to explore their possibilities for therapeutic purposes.

It is well known that the first workers in the field of radiology were destined to pay a heavy price for their devotion. The repeated exposure of the skin to the action of the new rays set up a disease in skin known as X-ray dermatitis. Gradually the skin and even the deeper tissues of the hands and other parts that had been exposed to the action of the rays were destroyed. Extensive and painful sores appeared which penetrated deeply and resisted all attempts to induce healing, and in some cases cancerous change set in, necessitating the loss of a limb, and unfortunately, in a few cases, leading to a fatal termination. It was natural to surmise that an agent with such terrible powers for evil as X-rays possess might, in suitable small doses, be converted into a means of salvation, in the same way as many deadly poisons—strychnine, opium, digitalis, and mercury—have become the physician's most potent and useful remedies when rightly administered.

It was found that certain diseases of the skin yielded very readily to carefully administered applications of X-rays; and to-day ringworm, so difficult to eradicate by ordinary methods of treatment, is almost universally treated by X-rays. Prior to this treatment primary schools were deprived of numbers of their pupils for long periods, averaging two years for each child, but now the disease is usually eradicated in three months.

Other diseases which have been treated with a large degree of success by irradiation are: Tuberculous glands; other gland enlargements, such as occur in lymphadenoma (Hodgkin's disease); uterine fibroids; exophthalmic goitre (Graves's disease); blood diseases, such as leukæmia; and some forms of gout, rheumatism, and neuritis: in these painful disorders X-ray treatment relieves pain even when it cannot achieve a cure.

In view of the successful application of X-rays in dispelling enlarged glands, the question naturally arose: Have we here a therapeutic agent which can cure that most dreaded of all diseases—cancer? The answer to this important question was sought with diligence, and at first with much promise. But its limitations soon became apparent, and to this day the results of X-ray treatment of cancer have not fulfilled our greatest hopes. True, many cancerous masses can be destroyed and made to disappear by this treatment, yet a genuine cure does not always follow. Other growths may appear in inaccessible places, or general dissemination of cancer may set in. Early removal by operation is still the safest method of dealing with a cancerous growth. The removal may, however, be advantageously followed by the systematic irradiation of the operation area, so as to destroy any cancerous cells that may have been left behind. We must not (nay, we dare not) despair of the successful treatment of cancer. Recent researches, however, lead to the conclusion that the road to salvation is in the prevention rather than in the cure of the disease. In these researches X-ray observations of the digestive system occupy a prominent place. They have taught us that particular sections or points in the gastro-intestinal tract become so altered from their healthy state as to be specially liable to take on a cancerous change. We have learnt that toxic products, absorbed from the intestinal canal into the general circulation, give rise to deterioration of the tissues and render them liable to become cancerous as the result of some slight source of continued irritation such as would do no harm to healthy tissues.

The effects of X-ray exposures on white blood corpuscles are receiving increased attention, and to-day results are being obtained which are of great interest. We know, for instance, that the white cells of the blood play a leading part in the struggle with invading microbes. If particular kinds of white cells can be increased in numbers and in activity, we shall have gained a notable step in treatment. Already there are reports from more than one part of the world of promising results from treatment on these lines in cases of pulmonary consumption.

It will be seen from the foregoing brief account that important developments in the functions of X-rays in the direction both of diagnosis and of therapeutic application can be hopefully awaited. Every day we are learning more of the nature and properties of the various kinds of X-rays, the soft and hard primary rays, the homogeneous and other secondary rays; and knowledge is increasing regarding their action on the surface and within the body tissues.

It is safe to predict that in the coming years X-rays will play an increasingly important part in attaining the end and aim of all medical study—the prevention of disease and the maintenance of a high standard of health and efficiency in the community.—From the Jubilee number of *Nature* (London).

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